TRAVELS IN THE TWO SICILIES, & SOME PARTS OF THE APENNINES; TRANS FROM THE ITALIAN OF ABBE LAZZARO SPALLANZANI, VOL 3 ONLY (OF 4 VOLS) (MOSTLY ABOUT ISLANDS OFF N.COAST OF SICILY & VOLCANIC SUBSTANCES) 8½"x5", SHEEPSKIN, GILT SPINE, COVERS WORN, 1798

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VOL 3 ONLY

TRAVELS

IN THE

TWO SICILIES,

AND

SOME PARTS OF THE APENNINES.

Tranſlated from the Original Italian of the

ABBE LAZZARO SPALLANZANI,

Profeſſor-Royal of Natural Hiſtory in the Univerſity of Pavia, and Superintendant of the Imperial Muſeum in that City; Fellow of the Royal Society of London; and Member of the Academies of Pruſſia, Stockholm, Gottingen, Turin, Padua, &c. &c.

IN FOUR VOLUMES.——WITH ELEVEN PLATES.

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TRAVELS

TRAVELS

IN THE

TWO SICILIES, &c.

CHAP. XVI.

LIPARI.

PART THE SECOND.

OBSERVATIONS MADE IN THE INTERIOR PARTS OF LIPARI, AND SEVERAL OF ITS MOUNTAINS.

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iſſuing

iſſuing from ſubterranean conflagrations are ſo extenſive as at Lipari—Vitrifications of Campo Bianco, and the Monte della Caſtagna, which are found attached to thoſe of the Monte delle Stufe, the Monte San Angelo, and other places—Proofs that almoſt two-thirds of Lipari, which iſland is nineteen miles and a half in circumference, are compoſed of vitrifications—The materials of which this iſland is compoſed, principally derived from the petroſilex, felt-ſpars in the maſs, and horn-ſtones, in part ſimply fuſed by ſubterraneous combuſtions, and in a ſtill greater part vitrified—Notwithſtanding the immenſe accumulations of this vitrification, an extraordinary intenſity of heat not neceſſary to be ſuppoſed—An exception in the pumices originating from granite—Few notices left us by ancient authors relative to the fires of Lipari; though we know from indubitable authorities, that both the iſland and the city exiſted before the Trojan war—No eruption in this iſland deſcribed by Hiſtory—Feeble fires, viſible by night, alone ob-

ſerved in ancient times—This iſland, the produce of ſubterranean conflagration, had arrived at its greateſt dimenſions, before it was noticed by any writer.

TO acquire a juſt knowledge of the interior part of a mountainous vulcanized country, the beſt method, as it appears to me, is firſt to aſcend the higheſt mountain, and, after having examined the ſummit, to turn the eye downward, and obſerve the chain of ſmaller mountains that ſurround it. We may thus, at one glance, diſcover the form of theſe inferior mountains, their interchangeable connection, and the relations which they bear to each other, and to the primary mountain, with other important objects, which, had we firſt aſcended one of the lower eminences, we ſhould not have been able to aſcertain with equal preciſion and clearneſs.

After, therefore, having made reſearches, with the greateſt diligence, around the ſhore of Lipari, when I proceeded, according to my

my original intention, to explore, likewiſe, the internal parts of the iſland; I, firſt, aſcended to the ſummit of the Monte San Angelo, ſituated to the north of the city of Lipari; this being the higheſt mountain in the iſland. Here the whole of the iſland preſented itſelf, at once, to my view, and I could perceive that, far from having a conical figure, ſuch as is that of Stromboli, and in a certain manner of Vulcano, it is compoſed of groups of broken and half-deſtroyed mountains, confuſedly heaped together; which give it a moſt irregular appearance. It is evident that the volcanic fires have raged in many places, and that, from their too great proximity to each other, they have not been able to form thoſe diſtinct cones which are ſo obſervable in Veſuvius and on Etna. But the matters ejected by the ſuperior volcanos, pouring upon thoſe which iſſued from the lower, have produced in every part confuſion and diſorder. From the ſummit of Etna we may diſcover a multitude of ſubjacent craters, well characteriſed; but from

that of San Angelo I could not perceive one. There are, indeed, many openings and hollows to be ſeen, which once, perhaps, were fiery mouths; but none of theſe cavities have at preſent the figure of an inverted tunnel, poſſibly becauſe they have been in part filled up and deſtroyed by ſubſequent eruptions, or by time.

M. Dolomieu obſerved at the ſummit of this mountain a circular plain, ſurrounded by eminences ſhelving towards the inſide, which he imagined might be the remains of an ancient crater. This conjecture, after a careful examination of the ſpot, does not appear to me improbable. The ſame naturaliſt likewiſe ſuppoſes that this mountain, the height of which is nearly a mile above the ſea, was the firſt that was formed in the iſland, through which the volcano burſt forth, and which ſerved as a baſe and ſupport for the other mountains that were thrown up afterwards. This opinion is extremely plauſible; but the fact may likewiſe be, in my opinion, that this mountain,

at

at the time of its production, or very ſoon afterwards, had for its companion the Monte della Guardia, which looks towards the ſouth, and of which I have before ſpoken; both becauſe the latter is ſeparated from the former, and becauſe it is little inferior to it in height. From the ideas ſuggeſted by a view of the places themſelves, I conceive it not improbable that theſe two mountains, which riſe ſo much higher than the reſt, have been produced by two diſtinct volcanos, and were the firſt that emerged from the ſea, forming then two ſmall iſlands, which afterwards, enlarging their baſe, united into one; for it is well known that other volcanic iſlands originally conſiſted of ſeveral parts, which afterwards were joined. To theſe two mountains ſubſequent eruptions made new additions, until at length the whole of the iſland of Lipari was produced, which, from the eroſion of the rains and the ſea, is now certainly leſs than it once was.

From Monte San Angelo, I paſſed to the Monte

Monte della Guardia, which on the ſide towards the ſea preſents only ſteep and rugged precipices of lava, and, conſequently, is deprived of all vegetation and verdure; but on the land ſide, which is oppoſite in one part to the city, it is formed with gentle declivities, and covered with vineyards; for, as its ſoil is tufaceous, it leſs reſiſts cultivation than any other volcanic product. While ſtanding on the ſummit I was ſtill more confirmed in the opinion, that this mountain is not an acceſſary to, or prolongation of, that of San Angelo; but that it forms a whole of itſelf, and may be called primary equally with the other, from the diſtance between them, and the wide valley, running from eaſt to weſt, by which they are ſeparated.

Having viſited theſe two mountains, which are the loftieſt in the iſland, I proceeded next to examine the leſſer eminences, and found additional confirmation of what I have already obſerved; I mean, that theſe eminences have entirely loſt the true

true form of volcanic craters, ſo much have the matters ejected from them interſected each other, and confuſedly intermixed. The long and unknown ſeries of years that has elapſed ſince theſe eruptions, muſt, no doubt, have contributed to increaſe the confuſion. Excepting, therefore, ſome few flat places, and practicable declivities, which the inhabitants have rendered cultivable by great labour, Lipari is a ruinous pile of horrid precipices, rugged cliffs, and enormous maſſes; and there is no ſummit, or projecting part of a mountain, which does not exhibit manifeſt indications of its future fall and deſtruction. The materials of which theſe ruins are formed are pumices, enamels, and glaſſes, which I ſhall not deſcribe, becauſe they are partly the ſame, and partly extremely analogous to thoſe of which I have already given the deſcription.

Some of the natives, by the accounts they gave me, excited my curioſity to viſit a cavern ſituated in a ſmall plain called La Valle, about a quarter of a mile to the weſt of

of the city. This cavern has its mouth in a rock of decompoſed lava, and a man may walk into it to the diſtance of fifty paces. Its ſides are covered with effloreſcences of muriate of ammoniac, as were, likewiſe, thoſe of another ſmaller cavern in the ſame rock. This ſalt muſt have been formed by ſublimation, having been reduced to vapour by ſubterraneous fires, and thus attached itſelf to the ſides of theſe two caverns, as it is found attached in many other volcanic places; but of theſe fires and ammoniacal vapours no traces whatever now exiſt.

In this ſhort excurſion I found by the way a volcanic breccia, which, on account of the heterogeneous ſubſtances it contained, it would be improper to paſs without notice. It is found in large iſolated pieces, but I was unable to diſcover from what vein it derived its origin. Its principal ſubſtance is an earthy lava, of a blueiſh grey, a coarſe grain, and little hardneſs. In this were incloſed the following bodies:

Firſt,

Firſt, fragments of two kinds of lava; the one black, of a ſcaly fracture, and which moved the magnetic needle at the diſtance of two lines: the other of a grey ground, a very rough ſurface, an unequal fracture, which gave ſparks with ſteel, and contained ſmall plates of feltſpar. Both were of the horn-ſtone baſe, and emitted a ſtrong argillaceous odour.

Secondly, ſeveral pieces of vitreous lava, of a very beautiful colour, between a green and a blue: by its ſmoothneſs, clear fracture, its aſpect, and want of hardneſs, it reſembles the pitch-ſtone, or pitch-blende.

Thirdly, numerous ſmall pieces of a cinereous compact pumice.

Fourthly, pieces of a whitiſh ſemi-tranſparent glaſs.

Fifthly, ſmall pieces of a colourleſs glaſs, reſembling in tranſparency factitious glaſs. The largeſt piece was fourteen lines in length,

length, and eight in breadth, and was, like the others, buried in the breccia.

Theſe five ſpecies of volcanic productions were certainly not natural to the ſubſtance of the lava; for their fractures and angles are very viſible, and by carefully breaking the lava they may be extracted entire. We muſt therefore conclude that they were abſorbed and incloſed in the lava when it was in motion, and thus were conſolidated into one body.

In making theſe obſervations a doubt ſuggeſted itſelf. Though to the naked eye, and likewiſe to the touch, the vitreous lava appears perfectly ſmooth, yet, when viewed with a lens of a ſtrong magnifying power, its ſurface appeared full of very minute fiſſures. At leaſt, if this was not obſervable in all, it was in ſeveral pieces of both theſe kinds of glaſs. I therefore conjectured, that when theſe ſubſtances were in an ignited ſtate, a current of water might have paſſed over them; or that they ſuddenly came in

contact

contact with the cold air; unleſs we rather chooſe to ſuppoſe that theſe fiſſures were produced, when theſe vitreous bodies, in a frigid ſtate, were ſuddenly enveloped in the fiery torrent.

But the celebrated Stoves of Lipari appear to be the object which moſt excites the curioſity of travellers; I could not, therefore, omit to viſit them. I muſt, however, confeſs, that the road which led to them afforded me more inſtructive objects than the ſtoves themſelves.

Theſe ſtoves lie to the weſt of the city, at the diſtance of four miles, and ſomewhat beyond the ſummit of a mountain, which, after thoſe of San Angelo and della Guardia, is one of the higheſt in the iſland. The road I went was that which leads immediately from the city to the ſtoves, and the only one which can be travelled without great difficulty. It is in a great degree the work of rain waters, which have made a deep excavation in an immenſe maſs of tufa.

tufa. In more than one place, in this work, I have ſpoken of volcanic tufas, but almoſt always incidentally. The preſent ſpecies of this ſubſtance requires to be treated of ſomewhat more at length.

At the beginning of this work, when ſpeaking of the volcanic tufas of Poſilipo, I ſaid, and endeavoured to prove, that it was probable they were formed by ſlimy eruptions; though I would not deny that aſhes, ſand, and other ſubtile matters ejected by volcanos, and penetrated either by the rain-waters or thoſe of the ſea when they covered the baſes of the burning mountains, have been conſolidated into ſome tufas*. The tufa of Lipari, of which I now ſpeak, has every appearance of having been an earthy current. It begins at about a hundred paces from the city, and continues, without interruption, to beyond the ſummit of the Monte della Stufe, or Mountain of the Stoves. This mountain, like moſt of the others, varies conſiderably in its dif-

* See Chap. II.

ferent

ferent parts, in one place preſenting gentle declivities, and in another ſteep and rugged deſcents; here plains nearly level, and there precipices almoſt perpendicular. The tufa with which it is covered, takes exactly the ſame courſe; and ſometimes curves, and, as it were, waves on the ſurface: nor does it in the leaſt differ in its ſinuoſities and windings, from the moſt completely characteriſed currents of lava, which it likewiſe reſembles by being diſpoſed in beds lying one over the other, as appears in thoſe places which have been moſt corroded by the rain. I therefore was of opinion, that this tufa had been a ſtream, if I may uſe the expreſſion, of ſlimy ſubſtances, that had flowed down the mountain; as examples are not wanting of ſimilar eruptions, produced in the humid way, in the mountains Veſuvius, Etna, and Hecla.

But here a difficulty preſented itſelf in oppoſition to this hypotheſis. Had this part of the mountain been inundated by a torrent of water iſſuing from the earth,

when its violence had ceaſed, the more heavy bodies muſt have ſubſided to the bottom in obedience to the law of gravity, the leſs heavy have remained above them, and the lighteſt have occupied the higheſt place; which, however, is not the fact, ſince, as we ſhall ſee, at a ſmall depth within the tufa, are found large maſſes of lavas, enamels, and glaſſes. But it does not appear to me improbable that theſe maſſes may have been thrown out from ſome burning mouth, after the hardening of the tufa, within which they have not penetrated deep.

Not only the poſition and winding courſe of this tufa over the back and ſides of the mountain ſufficiently prove that it once flowed: its very nature is a ſtrong confirmation of this fact. It is not an aggregation of aſhes and ſand; a mixture of fragments of ſhoerls, feltſpars, and lavas decompoſed, and rendered earthy, and faſtened together by the action of the water, becoming ſo hard as to be cut into pieces proper

per for building, as is the caſe with many other tufas; but it is merely an argillaceous earth, reſembling, from its ſoftneſs, the hardened mud of rivers. Its colour is a dull grey, its ſtructure ſomewhat granular, and ſo yielding that it may be crumbled and pulverized between the fingers. It is light, adheres ſlightly to the inſide of the lip, emits a feeble argillaceous odour, and, when immerſed in water, greedily imbibes it in every part.

In the furnace it firſt acquired a reddiſh brown colour, and afterwards the black colour of iron. It became ſo hard that it gave ſparks with ſteel, without, however, vitrifying, except that its ſurface aſſumed a kind of vitreous varniſh.

The depth of this tufa is different in different parts of the mountain. In ſome places it is ſeveral feet deep, in others but a few, and in others there is ſo great a quantity of it that, notwithſtanding the excavations made in it by the rains, I was unable

to aſcertain its depth. But in every place where I could diſcover the bottom, I obſerved that it reſted on a bed of pumices, partly pulverized, and partly in detached pieces approaching to the globoſe form. They belong to the claſs of the lighteſt of theſe ſubſtances. It appears, therefore, indubitable that theſe pumices had been thrown out of the burning mouth of ſome volcano, before the flowing of the tufaceous current.

This tufa preſented a very unexpected phenomenon. On breaking it, its fractures exhibited ſmall black particles, which were diſtinctly recognized to be true coal, from their blackneſs, lightneſs, dryneſs, the facility with which they broke, and their ſmall degree of hardneſs. Some of them, likewiſe, when expoſed to fire in the open air, fumed, and became red hot; others emitted a little flame. The latter had not been perfectly reduced to coal, as the fibrous parts of the wood were ſtill to be ſeen. Theſe coals were ſmall cylinders from two

or

or three lines in length to twelve or fourteen, and of proportional thickneſs. They appeared to have appertained to branches of trees or ſhrubs; they are buried in the tufa at various depths, and are found, though thinly ſcattered, through its whole extent.

This fact, never before, to my knowledge, obſerved by others in volcanic tufas, might induce us to imagine that the two methods, the humid and the dry, had here been combined; and that the watery ſlime, when it flowed down the mountain, had been penetrated by the fire in ſuch a manner that it had inflamed, and converted into coal, the vegetables it met with in its way. This explanation is certainly not free from difficulties, as the reader, no doubt, already perceives; it therefore may appear more probable that the earthy inundation had involved, and carried with itſelf, theſe carbonaceous ſubſtances, which exiſted previous to its eruption, and which derived their origin from a ſhower of ignited matter having burned, but not entirely conſumed,

the few plants which feebly vegetated on the declivities of the mountain.

It has been already ſaid, that the rapid deſcent of the rain-waters on that part of the mountain which leads to the ſtoves, has corroded the tufa to a great depth; and it is in the middle of theſe corroſions that we meet with various volcanic bodies, which, together with others lying in the public road, merit well to be deſcribed.

Firſt, we find pieces of enamel of every ſize, which, though they are ſmooth without, when broken, have, within, an angular fracture. Their colour is a pale blue, they have no great brilliancy, nor are they very hard, as they fly in pieces when ſtruck againſt the ſteel. The cauſe of the want of hardneſs in this enamel, may be aſcribed to the fiſſures, of which it is full; and theſe, perhaps, are to be attributed to the pieces of enamel being red-hot when they fell into the tufa not yet dry. The felt-ſpars it contains have the ſame cracks, and probably from the ſame cauſe.

In

In the ſame places is found another kind of enamel containing a great number of ſmall bodies, which I will not abſolutely affirm to be garnets, becauſe I was not able to analyze them in the humid way; but their external characters, together with the proofs furniſhed by the dry way, almoſt induce me to conclude them ſuch. In all my volcanic reſearches I have never met with any ſimilar. In general they have a bulbous figure, and are of a blackiſh colour, which in ſome inclines to a red. Their ſurface is ſmooth and ſhining, their recent fractures lamellar, perfectly vitreous, and will cut glaſs. The largeſt are about three lines and a half in thickneſs, and are opake; the ſmalleſt, about the third part of a line, and are ſemi-tranſparent. They give ſparks with ſteel, and melt in the furnace into a black and ſcoriaceous enamel. Theſe characters, taken together, certainly give them a great reſemblance to garnets: I ſhall not therefore heſitate to claſs them with that ſpecies of ſtone; as their not being cryſtallized is of little importance, ſince we know that there are alſo amorphous garnets.

While employed in the examination of theſe ſtones, I reſolved to compare them with the Veſuvian garnets; for, in my excurſion to that volcano, I had collected ſeveral different ſpecies of them on Monte Somma, which is the ancient Veſuvius. I made ſeveral experiments on four of theſe, of which the following is the reſult.

The firſt ſpecies is found in a lava with a horn-ſtone baſe, of a yellowiſh grey colour, an unequal ſurface, and of a conſiſtence little different from earthy, from the great alteration it has undergone; not, as far as appears, from ſulphureous exhalations, but from the action of the atmoſphere. The garnets it contains have likewiſe ſuffered injury, having loſt a part of their native luſtre, and being eaſily broken or crumbled to pieces from the multitude of minute fiſſures and cracks in them. They, however, retain ſomewhat of the vitreous character. Their colour is between a white and a grey. At firſt view their figure appears perfectly globular; but on extracting them from the ſtone, their matrix, (which may eaſily be done,)

done,) and attentively examining them, they are found to have facets, though it is not poſſible to aſcertain the number of them, as many of the angles have been defaced by time. I ſhall only obſerve, that having broken one of theſe garnets into two equal parts, the perimeter of each half was octagonal. This fracture at the ſame time ſhewed the texture of the garnet, which is compoſed of very thin circular leaves. Theſe garnets are of different ſizes, from four lines and a half to one ſixth of a line.

The furnace reduces the matrix-lava to a compact enamel of the colour of pitch; but it leaves the garnets untouched, which only become ſomewhat whiter, more vitreous, and more hard. The blackneſs of the enamel being a contraſt to the whiteneſs of the garnets, a great number of the latter become conſpicuous, which before were not viſible in the lava; and, notwithſtanding their extreme minuteneſs, they remain uninjured by the fire.

The

The garnets of the ſecond ſpecies are contained in a lava which has for its baſe a ſoft horn-ſtone. They are larger than the former, and entirely opake. They are white as ſnow, and more brilliant in their fractures than the preceding. Many of them are of a round figure, and manifeſtly ſhew a cryſtallization in various facets; which, however, it is impoſſible to number, as they break in pieces if we attempt to extract them from the lava. Many others of them are of very irregular forms.

Several of this ſecond ſpecies of garnets incloſe within them ſmall priſmatic ſhoerls, of the colour and luſtre of aſphaltum, which probably pre-exiſted completely formed, and were taken into the moiſture from which the garnet derived its origin.

Theſe garnets are, likewiſe, infuſible in the furnace, though the lava is converted into a porous ſcoria.

The third kind is ſtrongly infixed in a heavy

heavy lava, which alſo has for its baſe the horn-ſtone, is of an iron-black, compact, but not ſufficiently hard to give ſparks with ſteel. The garnets, which are of a yellowiſh white colour, and ſome of them four lines in diameter, for the moſt part have clefts or fiſſures, but in ſuch a manner that in the recent fractures the ſurface reſembles a round polypetalous flower.

The furnace melted the lava, but not the garnets, which only acquired the red colour of copper.

The garnets of the fourth and laſt ſpecies have four-and-twenty facets, and are ſemitranſparent, white, and vitreous. Their matrix is a compact lava of a horn-ſtone baſe, which emits an argillaceous odour. In the the furnace it changes into a black enamellar product, but the garnets remain untouched.

On comparing theſe reſults with others before detailed, we ſhall find that the ſtructure

ture of the Veſuvian garnets, ſo far as it is vitreous and lamellar, is ſimilar to that of thoſe of Lipari; but that, when expoſed to the fire, a difference is found between theſe two ſtones, the one eaſily melting in the furnace, and the other proving refractory.

Finding, therefore, that theſe four ſpecies of garnets were infuſible in the furnace, though continued in it for ſeveral days, I had recourſe to oxygenous gas (or dephlogiſticated air), by the action of which they all melted, though ſlowly. When the matrix lava flowed like common glaſs, the ſmall pieces of garnet within it remained unchanged; but at length fuſed, though without incorporating with the lava, ſo as to form a homogeneous whole.

Thoſe chemiſts and naturaliſts, who, before me, have made experiments with fire on the Veſuvian garnets, have deſcribed reſults ſimilar to thoſe I obſerved. Bergmann ſays theſe garnets melt with the blowpipe alone, but a vehement fire is neceſſary.

ſary *. Sauſſure tells us, that a ſpotted lava *(lave à oeil de perdrix)* which he found on Monte Somma, acquired, after fuſion, a black vitrified ground, but that the polyhedrous grains of this lava remained unchanged in the moſt violent fire; and by polyhedrous grains it is evident that he means what I and others have called garnets †. With reſpect to the action of oxygenous gas upon them, we may refer to Ehrmann, in his work on the Air of Fire. "The white opake garnet of "Veſuvius," ſays this writer, "differs from "garnets properly ſo called, in this, that it "melts with extreme difficulty (with the "aſſiſtance of oxygenous gas is here to be "underſtood), and at length, after continual "ebullition, becomes a maſs perfectly ſimi-"lar to quartz, even in its fracture, and "which crackles in like manner between "the teeth."

This kind of ebullition I have obſerved in the four varieties of garnets above men-

* De Productis Vulcanicis.

† Voyage dans les Alpes, Tom. I.

tioned,

tioned, when they were in a ſtate of fuſion. The firſt and third, likewiſe, produced two ſmall maſſes reſembling quartz, but thoſe of the ſecond and fourth variety were ſpongy. It is very poſſible that this author only made his experiments on one ſpecies.

Some learned naturaliſts are of opinion that the garnets of Veſuvius are improperly ſo denominated; firſt, becauſe they contain no iron; ſecondly, becauſe they fuſe with difficulty; and, thirdly, becauſe they differ in the proportionate qualities of their conſtituent parts from thoſe of true garnets. Theſe reaſons, however, do not appear to me ſufficient to exclude them from being claſſed with this kind of ſtones. It is true, that iron is uſually contained in garnets; but it is not eſſential to them; as has been obſerved by Bergmann, who, in tranſparent garnets, found only $\frac{4}{100}$ parts of this metal. The abſence of iron, probably, therefore, renders them ſo difficult to fuſe. With reſpect to their conſtituent parts, the Swediſh chemiſt (Bergmann) has obſerved, that the principal

principal of theſe is ſilex, the next alumine, and that which is leaſt of all in quantity, lime. This analyſis agrees with that made by Achard on ſome of the pureſt Bohemian garnets; and ſuch a proportion of the conſtituent principles is ſufficiently ſuitable to that of the garnets of Veſuvius, in which Bergmann found about 55 parts of ſilex, 39 of alumine, and 6 of lime. And though the proportion of the ſilex to the alumine is not entirely the ſame in both theſe ſtones, the difference is not ſo great, in my opinion, as to induce us to conſider them as two diſtinct ſpecies; as will appear by comparing the numbers 55 and 39, which expreſs the quantities of ſilex and alumine in the Veſuvian garnets, with the numbers 48 and 30, denoting thoſe of the ſame two earths, in the Bohemian garnets, analyzed by the before-cited chemiſt of Berlin (Achard).

To return for a moment to the garnets of Lipari: theſe do not ſo tenaciouſly adhere to their baſe as we almoſt always find the felt-ſpars and ſhoerls; but, like other garnets, are

implanted in it in ſuch a manner that they may be eaſily detached without breaking, leaving the exact impreſſion of their figure in the enamel. This enamel, which is compact, heavy, and of a grey cinereous colour, is found in detached pieces, both in the road and in the tufa; and is the firſt production which preſents itſelf, after leaving the city to proceed towards the ſtoves.

Continuing our journey ſtill further along this road, we find in it, and likewiſe within the tufa, very curious mixtures of a white argillaceous earth and black enamel; both of which are ſo mingled and kneaded together, that we can ſcarcely find a quantity of this earth of the ſize of a pea, which does not contain ſeveral particles of this enamel; and very few, indeed, are the pieces of enamel that contain none of this earth. It has an earthy odour, and adheres to the tongue.

In the ſame ſituations where this peculiar mixture is found, we likewiſe meet with an enamel containing garnets, ſimilar to thoſe above

above-mentioned, but larger, and more approaching to a globular figure. It is remarkable that this enamel, in ſome places, forms one whole with ſome pieces of lava of a horn-ſtone baſe, which alſo contains garnets.

I ſhall briefly diſtinguiſh four ſpecies of lava, each of a horn-ſtone baſe, which are met with, in detached pieces, on the road to the Stoves.

The firſt has a fibrous fracture, the colour of iron, ſome appearance of poroſity, ſufficient hardneſs to give ſparks with ſteel, and the power to move the magnetic needle at the diſtance of a line and a quarter. It emits an earthy odour, and contains felt-ſpars.

The ſecond is of a black-grey colour, and, though compact, rather ſoft. Almoſt one half of it conſiſts of rhomboidal felt-ſpars.

The third only differs from the ſecond by being ſomewhat more compact, harder, and containing fewer feltſpars.

The fourth, which in ſolidity, weight, and hardneſs, exceeds the three preceding, has a black ferrugineous colour, an earthy fracture, adheres ſlightly to the tongue, and emits the uſual argillaceous odour. It moves the magnetic needle at the diſtance of half a line.

All theſe four kinds of lavas are changed, in the furnace, into vitreous ſcoriæ, but without the fuſion of their feltſpars.

Having mentioned theſe, it will be neceſſary to deſcribe, ſomewhat more at length, another ſpecies of lava, which is enriched with a great number of extremely beautiful volcanic chryſolites.

This lava has for its baſe a ſoft horn-ſtone: it is of a dark brown colour, and unequal in its fractures on account of the fiſſures

which ſeparate its parts. It is found in detached pieces, like the four preceding lavas, but theſe pieces are rare. It gives but few ſparks with ſteel, emits a ſlight argillaceous odour, and acts on the magnetic needle at the diſtance of a full line. In conſequence of its numerous fiſſures it is rather light, and when ſtruck with a hammer is ſomewhat ſonorous. I omit to mention ſome ſmall ſcales of feltſpar incorporated in it, and proceed to the examination of the chryſolites.

Theſe, when ſituated in the external parts of the lava, which have ſuffered by the influence of the atmoſphere and elements, readily attract the eye, by their lively colour, which is between a green and a yellow; but in the recent fractures they ſhine with much more brilliant colours. The moſt conſpicuous are the golden-yellow, and the fine graſs-green, with which, ſometimes, is mixed a fire-red, tempered with a tinge of purple. If theſe chryſolites are expoſed to the immediate light of the ſun, and viewed

under certain angles, their colours become much more lively and bright. Many of them are amorphous, but ſome are quadrangular priſms. Their ſurface, in the fractures, ſhines with a glaſſy brilliancy, and is ſometimes ſmooth, and ſometimes rough, according as the plates of which the chryſolites are compoſed may have been broken. The ſmall fragments of them are angular and ſemi-tranſparent. Theſe chryſolites give ſparks with ſteel, and cut glaſs nearly like rock-cryſtal. The largeſt are not leſs than three lines and a half in length, but the ſmalleſt can ſcarcely be diſcerned by the naked eye. They are ſo firmly infixed in the lava, that only fragments of them can be detached.

The fire of the furnace, and that of the blow-pipe, not only will not fuſe theſe minute ſtones, but are unable to injure them either in their colours or texture. Oxygenous gas (dephlogiſticated air) alone diſcolours them, and melts them into a globule, of a white colour, but without brilliancy.

Though

Though it was not known till the preſent time that Lipari afforded volcanic chryſolites, they had been before found in other volcanized countries, as in Vivarais and Velay, by M. Faujas, and on Mount Etna by M. Dolomieu. But on comparing their chryſolites with mine, I find certain differences and reſemblances, which it will be proper to enumerate.

The chryſolites obſerved and deſcribed by M. Faujas, when examined with the lens, are found to be compoſed of an aggregate of arenaceous grains, more or leſs fine, and more or leſs adherent; ſcabrous, irregular, and ſometimes forming cruſts and ſmall ſandy ſcales; but, for the moſt part, having the appearance of angular fragments united by inſertion into each other.

The chyſolites of Lipari have nothing of this nature in their ſtructure. I broke ſeveral of them, and examined their fragments with the microſcope; but they never appeared to me granular, but always ſmooth

and glaſſy. The moſt minute parts of theſe chryſolites exhibited the ſame aſpect they preſented when whole.

I muſt not omit to mention another difference of importance, which is, that the chryſolites of Lipari are only a few lines in length, whereas thoſe deſcribed by M. Faujas are ſometimes ſeveral pounds in weight.

They agree, however, with mine in their inſuſibility in an extremely active fire; for thoſe on which he made his experiments reſiſted the fire of common furnaces, however violent and continued it might be, and could not be reduced to a ſtate of fuſion but by the aid of oxygenous gas.

The colours of both are ſometimes the ſame. I ſay ſometimes, for M. Faujas informs us, that ſeveral of his chryſolites were only of one colour; a green, or topaz-yellow.

The traits of reſemblance and difference between

between the Lipareſe and Etnean chryſolites will be ſeen by comparing the deſcription I have given of the former with what M. Dolomieu ſays of the latter, in the work I have frequently cited. He tells us, that ſome of the chryſolites he found there are amorphous, others cryſtallized in tetragonal or hexagonal priſms, ſometimes with an hexagonal pyramid; that their fracture is partly conchoidal, and partly lamellar; that they are harder than quartz; that they are more or leſs tranſparent; that their colour is a greeniſh yellow, with various tinges, and that they are fuſible in a ſtrong fire. He does not give their ſize, but they cannot be large; both becauſe he calls them *grains*, and becauſe thoſe which I obſerved in ſome lavas of Etna were very minute.

I have deſignedly called the chryſolites of Lipari, *volcanic* chryſolites, not merely becauſe they are found within a lava, but to preſerve a diſtinction between them and the gem of that name; ſince I know that ſome reſpectable authors are of opinion, that the

volcanic ſtones which, from their greeniſh yellow colour, and other circumſtances, reſemble that gem, and therefore are called chryſolites by the Volcaniſts, differ from them entirely in their component parts, and ſeveral of their external characters. To this opinion I can make no objection, though, in deſcribing theſe ſtones, I have adopted the name by which they are uſually known. It muſt be obſerved, however, that ſome of their properties ſhew they cannot be claſſed as ſhoerls, among which ſome naturaliſts generally place the chryſolites of volcanos.

It remains likewiſe to ſpeak of a ſtone which was the laſt of the products that offered themſelves to my obſervation, as I proceeded along the declivity of the mountain leading to the Stoves.

This ſtone is a porphyry, the baſe of which is the petroſilex, containing feltſpars with ſeveral faces, and brilliant in the fractures, and blackiſh irregular ſhoerls. The baſe

baſe has the red colour of brick. It is found in detached maſſes, ſome of which weigh ſeveral thouſand pounds. It is compact, and ſcaly in the fractures. The pieces broken from it are irregular; the thinneſt are tranſparent at the edges; and they give ſparks moderately with ſteel. The colour of the baſe has given the feltſpars a reddiſh tinge, as we ſee in certain oriental porphyries.

But has this porphyry ſuffered fuſion, or is it in its natural ſtate, and, at moſt, calcined when it was ejected by the volcano? I cannot pretend poſitively to decide; but I incline to the latter opinion more than to the former, ſince an alteration is viſible, even in the internal parts, which appears to be the effect of a true calcination.

In the furnace, the ſubſtance of this rock becomes ſoft, but does not fuſe: the feltſpars remain unchanged, but the ſhoerls are vitrified.

The

The ſpacious and deep excavations made in the tufa by the rain-water, and which extend from the bottom of the mountain to the ſummit, afforded me an opportunity to diſcover and examine the ſtony ſubſtances I have deſcribed; for it was only in thoſe excavations that they were viſible: in every other part nothing appeared but the naked ſuperficial cruſt of the tufa. None of theſe ſubſtances are diſpoſed in currents; they are all detached; and thus render it probable that they fell into the tufa after having been thrown up into the air in volcanic ejections.

When we have reached the ſummit of the mountain, an ample plain opens, formed of the ſame tufa, but become earthy, in which corn is ſown, and a few vineyards are planted. Here we find numerous pieces of a ſhining glaſs, which is ſemi-tranſparent, of a blackiſh colour, and ſome of the fineſt and pureſt to be found in Lipari. As I wiſhed to diſcover the origin of this ſubſtance, I cauſed the place where it is found

found to be dug into. The tufaceous earth is there about three or four feet deep. The pumices lie immediately under it, and among them this glaſs is found, in conſiderable quantities. It has probably been turned up, and brought to the ſurface, by the plough, or other ſimilar inſtruments uſed to prepare the earth for ſowing with corn.

Beyond this plain there is a gentle deſcent of about two hundred feet in length, at the end of which are the Stoves. Whatever prepoſſeſſion in their favour the traveller may have conceived from hearing ſo much of them, he loſes it the moment he ſees them. They form a group of four or five caves, more like to the dens of bears than the habitations of men; and which exhibit much leſs of art than the edifices framed by the beaver. Every cave has an opening at the bottom, through which the warm and humid vapours enter, and another in the top through which they paſs out. I entered one of theſe, but was unable to remain long in it, leſs from the heat, for the

the thermometer ſtood at only $48\frac{2}{3}$ degrees, than from I know not what of a ſuffocating nature which the air had in it. Theſe Stoves now retain little more than their name, and are nearly deſerted. In fact, though they ſtill retained their virtue, and were efficacious in the cure of various diſorders, how would it be poſſible to make uſe of them, when they are deſtitute of every convenience neceſſary to that purpoſe?

When M. Dolomieu viſited them, the whole ground on which they ſtand was penetrated with hot vapours, which, under the form of a thick ſmoke, iſſued from ſmall apertures of about an inch, or two inches, in diameter. When I was there, circumſtances were much changed, as uſually happens in volcanos, where the preſence of fire manifeſts itſelf ſometimes more and ſometimes leſs. There was then only one aperture, of about an inch in diameter, from which, from time to time, iſſued a thin ſtream of ſmoke, with a ſtrong ſulphureous

ſmell. Having enlarged this aperture, I found it ſurrounded by a ſmall quantity of ſoft ſulphures of iron (pyrites) generated by the union of iron and ſulphur. The Abbate Trovatini, whom I have cited in another place, likewiſe atteſts, that, at certain times, ſeveral ſtreams of ſmoke aſcended round the Stoves; and I ſhall add, that, beſides the ſtrong ſmell of ſulphur, which I perceived on approaching the place, the ground became hot, and the fetor increaſed, on digging to about the depth of a foot: from which it may be concluded, that under the Stoves and the ground adjacent, ſome remains of ſulphureous conflagration ſtill continue *. The Stoves, and the warm baths,

* It has been ſhewn, in Chap. XIII, that the decompoſitions of different products of Stromboli and Vulcano do not derive their origin from the muriatic acid, to which, according to M. Sage, the principal alterations of volcanic ſubſtances are to be aſcribed, but to ſulphureous-acid exhalations. The decompoſitions in the environs of the Stoves of Lipari, I am of opinion, with M. Dolomieu, are to be attributed to the ſame cauſe, the exiſtence of which is ſufficiently proved by the remains

baths, of which we ſhall ſpeak below, are the only places in the whole iſland where any ſigns are to be found of as yet unextinguiſhed volcanos.

M. Dolomieu, after having deſcribed the Stoves of Lipari, proceeds to ſpeak of the alterations cauſed by the ſulphureous-acid vapours on the lavas of this place, remarking that all of them, beſides having become ſofter and lighter, have loſt their primitive colour, and aſſumed a white tinge, mixed with yellow, red, violet, and other colours, which the oxides of iron uſually produce. He obſerves likewiſe, that they are coated with a thick cruſt of ſulphates of lime (ſelenite or gypſum), which ſulphates penetrate likewiſe to the internal parts, and that ſome lavas are covered with that kind of iron ore which is called ſlimy *(fungoſa)* or bog ore. He then very ingeniouſly explains in what manner, by means of a combination of the

mains of ſulphureous fumes, and the quantity of ſulphates of lime, which I ſhall preſently have occaſion to deſcribe.

ſulphuric

ſulphuric acid with different earths, the lavas have become lighter and variouſly coloured.

As I viſited the Stoves three ſeveral times, and examined with great attention the lavas that had ſuffered alteration by the action of the ſulphureous acid, I am enabled to add, to the obſervations already given, ſome others which I believe to be new, and which I ſhall here briefly ſtate.

It was an object equally important and curious to aſcertain to what kinds of lavas ſtill remaining in the ſtate in which they were left by the fire, thoſe belong which we now ſee decompoſed by acids; and as the obſervations I had made at Solfatara di Pozzuolo and other places, had taught me that the decompoſition diminiſhes, the deeper it enters into the ſubſtance, I conceived that the moſt proper means to obtain this knowledge would be, to break fragments of the lava, and examine the internal parts, to find how far the decompoſition had penetrated.

The

The greater part of the decompoſed lavas of the Monte delle Stufe are, externally, of a reddiſh white; and ſome are of a blackiſh colour. I firſt examined the latter; and preſenting their ſurface to the full light of the ſun, I diſcovered ſomething of a brilliant appearance which invited me to examine it with the lens. It proved an aggregate of innumerable globules of hæmatitic iron, which beautifully cover the ſurface of theſe lavas.

I detached a conſiderable number of theſe globules, and found that on trituration they aſſumed a red colour, which is the property of the dark hæmatites. This was, therefore, a pure martial oxide, depoſited here, and formed into globules; and under that aggregate lay another oxide of red, but earthy iron. The lava ſtill deeper was of a white colour, interſected with parallel ſtreaks of a reddiſh black, or lightly ſhaded with a yellowiſh tinge.

Theſe lavas are ſoft, light, and compact: they

they adhere to the tongue, have the conſiſtence of clay, but do not emit its odour. They ſeem to be ſimple lavas, no extraneous bodies appearing in them. It is obſervable that every fracture is conchoidal; and that, when ſtruck, they cauſe a ſound ſimilar to that of ſome kinds of petroſilex; which has induced me to ſuſpect they belong to that ſpecies of ſtone: a ſuſpicion which is confirmed by examining deeper within the fractures; ſince at the depth of two feet, or thereabouts, a grey colour takes place of the white, and the other external appearances diminiſh; the lavas begin to aſſume a ſiliceous aſpect, and give a few ſparks with ſteel. Still deeper we perceive without the leaſt doubt that theſe lavas have a petroſiliceous baſe, and contain a few ſhoerls, which do not appear in the decompoſed parts, probably becauſe they are themſelves decompoſed.

Theſe obſervations, which were made on ſome lavas of a black colour on the ſurface, are likewiſe true of ſeveral others, which, externally, are of a reddiſh white. The ap-

pearances in them are, eſſentially, the ſame. The red colour in the internal parts inſenſibly vaniſhes; the grey by degrees ſucceeds the white, which, ſtill deeper, acquires a luſtre, the lava at the ſame time becoming harder, and at length diſtinctly exhibiting all the characters of the petroſilex.

One of theſe lavas, ſtreaked with white and a clear red like that of the peach-flower, is ſpotted on the ſurface with points almoſt pulverulent. Theſe are decompoſed feltſpars, though they ſtill retain a reſidue of cryſtallization. This lava has been more changed by the acids than the others, being ſofter, and even pulverable; though at the depth of two feet it is hard, heavy, of a black-grey colour, evidently has a petroſiliceous baſe, and contains feltſpars which are perfectly entire.

In deſcribing the variouſly decompoſed lavas of Solfatara, we have ſeen that feltſpars are a kind of ſtones which ſtrongly reſiſt the action of acids. It frequently

happens, that their baſe is completely decompoſed, while they are ſcarcely in the leaſt changed. As, therefore, in the preſent lava, the feltſpars are decompoſed equally with their baſe, we muſt be convinced that the ſtrength of theſe acids muſt have been very great. In general, theſe lavas at their ſurface are ſoft, like dough, and almoſt ſaponaceous; characters that uſually accompany theſe decompoſitions.

We muſt not omit to notice a lava of the breccia kind, the baſe of which is likewiſe petroſilex, and in which the action of the acids has extended only to the depth of a few inches. This baſe, even near the ſurface, has not entirely loſt its natural colour, reſembling that of iron, and in it are incorporated irregular ſmall maſſes of whitened and pulverulent lava. Theſe, therefore, have yielded more to the decompoſition than the baſe that contains them. At a greater depth we find them unaltered; and they are then only fragments of lava of a horn-ſtone baſe.

Though many of the lavas of the Stoves of Lipari have ſuffered by the ſulphureous-acid vapours, there are ſome that are entirely unchanged. I ſhall only deſcribe one, which is ſo well preſerved that it appears to have been produced but yeſterday by the volcanic gulph. If we ſcale the ſurface of it, where it projects in large maſſes from the earth, it appears of a dark iron colour, has an extremely compact grain, and a conchoidal fracture. The ſcales at the edges are ſharp and cutting, and give very lively ſparks with ſteel. It is one of the heavieſt and hardeſt among the lavas, and puts the magnetic needle in motion at two lines diſtance. It has for its baſe the petroſilex, containing very brilliant feltſpar needles.

This lava, therefore, has not been in the leaſt affected by theſe acids, not, probably, becauſe it was able to reſiſt their ſtrength, but becauſe it was not expoſed to their action. The places under which the conflagrations of a volcano burn, have numerous apertures and fiſſures through which iſſue ſulphureous

ſulphureous fumes; and when lavas are ſituated around or within theſe, they will be more or leſs affected by them. But in the ſame tracts of ground there are more places than one impenetrable to theſe fumes, and there, in conſequence, the lavas ſuffer no other alterations than thoſe produced by time. Theſe interrupted exhalations of ſulphureous vapours I have obſerved at Veſuvius, Etna, and Stromboli, and have noticed them before in my accounts of theſe volcanos. It is only to be remarked that, at the Stoves of Lipari, the quantity of decompoſed lavas being very great, and extending for the moſt part to a great depth, the ſulphureous-acid vapours muſt have there iſſued in extraordinary abundance, and at the ſame time have been of long duration. The intenſity of them, and their conſequently greater efficacy, might, indeed, have ſupplied the place of long continuance; for I have obſerved, that when the lava of Veſuvius flowed before my eyes, and ſeveral of its lateral branches had ceaſed to move, two of theſe, which had been penetrated

by a thick cloud of the fumes uſual there, were already half decompoſed, though they were evidently parts of that current which, but a few months before, had been diſgorged by the ſide of the mountain. Laſtly, according to the different qualities of the lavas, and as they may be compoſed more or leſs of calcareous, argillaceous, or martial principles, all combinable with ſulphureous acids, a greater or leſs decompoſition will be produced.

The different degrees of decompoſition in lavas render them ſometimes more, and ſometimes leſs ſuſceptible of fuſion in the furnace. The parts not decompoſed will fuſe. A beginning decompoſition renders them ſtubborn, and, when it is complete, they entirely reſiſt the fire. The cauſe of theſe differences appears to me ſufficiently evident. The more earths are pure the more they reſiſt fuſion. All thoſe hitherto known are infuſible, except in very violent fires. Their mixture facilitates their fuſion, as they thus become a reciprocal flux; and

we

we know that fuſion readily follows, when ſilex, alumine, and lime are mixed in the proportion of 3, 1 and 1. There was no lava on which I made experiments, in which I did not find theſe three kinds of earth; and though they might not be combined exactly in this proportion, their combination was yet ſuch as to render almoſt every lava fuſible in the furnace. The lime, which, in the dry way, acts as a flux to the ſilex, is in a great degree diminiſhed in the decompoſition of lavas, forming ſulphate of lime by its intimate union with the ſulphuric acid; and hence we have one impediment to the fuſibility of theſe lavas. The diminution of the alumine, ariſing from its combination with the abovementioned acid forming ſulphate of alumine, which is afterwards detached and carried away by the rains *, will likewiſe be another obſtacle;

* To prevent any ambiguity, it may be proper to repeat what I have ſaid in Chap. II, that the pretended tranſmutation of ſilex, or any other earth, into argillaceous earth, in the decompoſition of lavas, has no exiſtence; ſince, in this caſe, that earth likewiſe is diminiſhed, from the cauſes alleged above.

to which we may add a third, which is the loſs of the iron, likewiſe an aid to fuſion.

Theſe ſulphates, which for the moſt part accompany lavas, preſent a pleaſing ſpectacle to the naturaliſt. Their colours are infinitely varied. Thoſe which are moſt prominent to the eye, are the roſe colour, violet, and orange, and they are the more conſpicuous becauſe they are generally placed on a white ground.

I have obſerved three kinds of ſulphate of lime, independent of ſeveral varieties which I omit. The firſt is compoſed of thin plates, parallel to each other, cloſely united, brilliant, compact, and opake. They form ſtrata or beds of different thickneſs, ſometimes more than a foot, and theſe ſtrata are eaſily detached from the lavas to which they adhere.

The ſecond ſpecies is filamentous, having either parallel or ſtellated filaments, in which latter caſe the filaments form a kind of pyramids, which have their apices in one

common centre, and their baſes at the circumference. We find ſome very large pieces of this kind, formed by the aggregation of theſe pyramids.

The third ſpecies is compoſed of thin and ſhining plates, ſomewhat elaſtic, tranſparent, very ſoft, and forms the indeterminate cryſtallization of ſulphate of lime called ſpecular ſtone; but this ſpecies is rare, and its cryſtals are always very ſmall. In theſe caſes the determinate and primitive cryſtallization of this neutral earthy ſalt is always wanting.

It is therefore evident that this variety of colours, ſuch as yellow, red, or violet, exhibited by the decompoſed lavas, is a conſequence of the iron pre-exiſting in them; which being, if not decompoſed, at leaſt greatly altered, by the ſulphureous acids, is variouſly modified, and aſſumes this diverſity of hues. The ſame cauſe operates, in like manner, on the ſulphates of lime, formed by the combination of the ſulphuric acid with

with the lime, which is laid open by the deſtruction of the adheſion of the conſtituent principles of the lavas, and variouſly coloured by the oxydated metal. The white colour of the decompoſed lavas, then, it is evident, is produced by the loſs of their iron; which agrees perfectly with experience, ſince, where the decompoſition has taken place, the lavas are incapable of moving the magnetic needle, whereas they conſtantly produce motion in it, ſome at the diſtance of two lines, and ſome at more or leſs, in the parts not decompoſed.

I ſhall conclude my obſervations on the productions of the Stoves of Lipari, with ſome intereſting remarks relative to ſeveral different ſpecies of zeolites, which I diſcovered in their vicinity. I ſhall deſcribe them ſeparately with their matrices.

Firſt ſpecies. The matrix containing this zeolite is a lava of a horn-ſtone baſe, of a dark-brown colour, granular in the fractures, and which ſcarcely gives ſparks with ſteel,

ſteel. It ſhews no indication of having ſuffered by the ſulphureous acids. It is full of ſmall long cavities, all in one direction, and which probably were produced when the lava was in a fluid ſtate. It is in theſe cavities that this ſpecies of zeolite is found. At firſt view it appears rather to be a ſtalactical calcedony, having the form of a cluſter of grapes. It is of a white pearl colour, inclining to a light blue, and gives ſome ſparks with ſteel. It has a ſiliceous fracture, and a degree of tranſparency. Three properties, however, eſpecially characteriſe it: firſt, that it forms a jelly with mineral acids; ſecondly, that it flaſhes or blazes at the moment of fuſion; and, thirdly, that it bubbles, and as it were boils, when in fuſion: and though neither of theſe characters excluſively appertain to the zeolite, all the three together ſufficiently fix the nature of this ſtone, which muſt be referred to the claſs of amorphous zeolites. The cluſtering grains may be extracted entire, as they attach to the lava but in a few points. The largeſt extend to five lines in length, by two

or

or three in breadth. The figure which I have called cluſtering, is the moſt uſual in this ſpecies of zeolite; though ſome are only oblong globules, of the ſame ſize with that of the ſmall cavities which contain them. They are, however, by no means found in every cavity; for, out of a hundred of theſe cavities, ninety contained no zeolite. This ſpecies is contaminated with a pulverulent, orange-coloured oxyde of iron.

The blow-pipe with difficulty melted it; and ſeveral ſeconds were required for its complete liquefaction, even with the aid of oxygenous gas. It then changed into a ſnowy-white enamel, full of bubbles. It has a lucid brightneſs when it begins to melt, and boils and bubbles up when in actual fuſion.

Second ſpecies. This is found in ſome pieces of the former lava, but its characters are different from thoſe of the preceding ſpecies. It coats over many of the cavities before

before mentioned with a thin cruſt, thus forming geodes, which, however, are not cryſtallized internally. This zeolite, which inclines to a white colour, is more tranſparent than the other, and, from its hardneſs, cuts glaſs, almoſt like rock cryſtal. The mineral acids have no effect upon it, not even when pulveriſed, though they convert the former ſpecies into a kind of jelly. When melted with the aid of oxygenous gas, it emits a thin brilliant blaze, and is changed, with ebullition, into a vitreous and white globule.

It is not unuſual to find within theſe zeolitic geodes, plates of very tranſparent ſulphate of lime. A hundred grains of this, pulveriſed, were put into ſix hundred of diſtilled boiling water. A ſolution was obtained, and the oxalic acid precipitated the lime.

Third ſpecies. This conſiſts of ovoid globules, externally dirty, from an earthy coating, but which internally are extremely white.

white. In the fractures we perceive that they conſiſt of a number of opake groups of fibres, ſtriated, ſilky, and ſhining, which diverge from the centre to the circumference of the globules, and thus form ſo many inverted cones. Theſe globules, ſome of which are more than four lines in diameter, perfectly fill the cavities of an argillaceous, light, extremely friable lava of a deep grey colour. Every cavity, however, does not contain a zeolite of this conformation: in ſome we find zeolitic ſtones with ſeveral facets, but ſo confuſed that the preciſe configuration of the cryſtals cannot be diſtinguiſhed. On attentive examination, they evidently appear to be formed of the ſame zeolitic ſubſtance, which, when it occupied the whole ſpace of the cavity, took the conformation of thoſe fibrous groups that have externally a globoſe figure; but when a part of this ſpace remained empty, it cryſtallized more or leſs. Theſe zeolitic ſtones always have in the middle a ſmall empty ſpace, where they are cryſtallized, forming a number of very minute geodes.

The

The blow-pipe preſently melts this third ſpecies, and with ebullition; a phoſphoreſcence precedes the fuſion, and the pearly globule which is the reſult, is a ſemitranſparent glaſs, abounding in bubbles. If this globule be broken, which requires rather a ſmart blow, the ſharp angles of the fragments will cut deep into glaſs.

This zeolite, ſoon after it has been put into acids, attaches to the ſides of the containing veſſel in the form of a cruſt, which cruſt preſently reſolves itſelf into a tranſparent tremulous jelly, ſimilar to that of hartſhorn.

Fourth ſpecies. The lava which contains this zeolite is of a horn-ſtone baſe, and forms two ſpecies, at leaſt two varieties; the one of which is granular, rough to the touch, and extremely friable; the other has a kind of ſoftneſs, a fine grain, and greater ſolidity. In colour, however, which is a grey, and in their argillaceous odour, both theſe varieties agree.

agree. This lava contains a multitude of zeolitic globules, from half a line to an inch in diameter. On breaking them, a vacuity is found within them, thus forming geodes of a cryſtallization more or leſs perfect. Wherever the zeolitic ſubſtance has been too confined in the cavity of the lava, the cryſtallization is extremely imperfect, in conſequence of the priſms being half-formed and confuſedly intermingled; but where that ſubſtance had a larger ſpace to develop itſelf in, the priſms are no longer ſo indiſtinct; many of them, at leaſt, are found to incline to a tetrahedral figure; and where the cavities of the lava have afforded a ſtill greater ſpace to the zeolitic matter, it has cryſtallized in tetrahedral priſms, of a diſtinct conformation. Every priſm has therefore four faces diſtinctly ſeparated. In ſome few places theſe priſms are terminated by a tetrahedral pyramid. Many of them are of a milky whiteneſs, and theſe are ſemi-tranſparent; but others have a tranſparency almoſt equal to that of quartzoſe cryſtals.

A ſingle

A ſingle cavity ſometimes contains ſeveral ſcores of ſuch priſms, while another ſhall contain but very few.

The blow-pipe eaſily melts theſe geodes with the uſual phenomena of ebullition and phoſphoreſcence, and the glaſs which is the reſult of the fuſion is ſimilar to that of the zeolite of the third ſpecies. A ſimilar jelly is likewiſe produced from it, and with equal promptneſs, in acids, except that it has a leſs degree of viſcoſity.

Fifth and ſixth ſpecies. Theſe two ſpecies of zeolites are contained within an argillaceous lava, of a dark-grey colour, light, and of an earthy conſiſtence: they both merit to be diſtinctly deſcribed. The firſt ſpecies conſiſts of a great number of ſmall ſpheres, white as ſnow, each occupying a cavity in the lava, and varying in ſize, the ſmalleſt being ſcarcely one third of a line in diameter, and the largeſt more than three lines. The ſurface of theſe ſmall ſpheres is not ſmooth, but ſomewhat rough, from an in-

finity of points which, viewed through the lens, are diſcovered to be ſo many minute tetrahedral priſms, diſtinctly defined. On breaking the ſpheres we perceive that the priſms are continued within them, and, becoming thinner, proceed to the centre; or, to ſpeak more properly, we find that the ſpheres are only the reſult of a number of priſms joined together lengthwiſe. The portion of the priſms that is immerſed within the ſpheres is opake; but that part which projects out has a degree of tranſparency. It is to be obſerved, that though the greater number of theſe minute ſpheres are perfectly ſolid, many of them have a round vacuity at the centre, ſometimes extending to one tenth part of the whole ſphere.

This zeolite is the ſofteſt of all the ſpecies hitherto enumerated, and may be ſcraped or cut with a knife.

The ſixth, and laſt, ſpecies is one of the moſt beautiful zeolites hitherto diſcovered by

by naturaliſts. It conſiſts of minute cryſtals, extremely clear and bright, which, having facets in every part, vividly reflect the light, and ſparkle like ſo many diamonds. Theſe are very numerous in the cavities of the ſame lava; but are unequally diſtributed, as ſome cavities contain but one of theſe cryſtals, while others have two, and others three, though the latter are rare. The largeſt do not exceed a line, and the moſt minute are ſcarcely a quarter of a line. While they remain in the lava, it is not eaſy to examine them as might be wiſhed; but many of them may be extracted without injury, and viewed, in every part, with the lens, at leiſure. We then perceive that theſe zeolites, where they reſt on the lava, are flat; but in their upper part incline to a globoſe figure; and that, there, their cryſtallization is apparent: that the *iſolated* cryſtals, I mean thoſe which in their formation grew without attaching to the other cryſtals, have eighteen facets, for the moſt part pentagonal, or tetragonal, but never triangular: that theſe iſolated cryſtals are extremely rare; the greater number being *aggregated*, that

is, confuſedly heaped upon each other in their formation: that, laſtly, though many of them may compare in clearneſs with the pureſt rock cryſtal, they are yet inferior in hardneſs, as they with difficulty cut glaſs.

I at firſt ſuſpected that theſe zeolites were a ſimple modification of the fifth ſpecies, which, wherever it had a free ſpace, had formed itſelf into theſe brilliant cryſtals, either iſolated or aggregate. But this conjecture was not confirmed by obſervation. It frequently happens that the white minute ſpheres which form the fifth ſpecies, occupy only one half, or even leſs, of the containing cavities, without ever taking the form of the ſixth ſpecies; but it is conſtantly to be obſerved that the tetrahedral priſms project farther beyond the convexity of the ſpheres, and have a greater tranſparency. They muſt therefore be conſidered as two diſtinct ſpecies.

This difference is ſtill more confirmed by the action of fire and acids. The latter do not act, at leaſt ſenſibly, on the ſixth ſpecies, though

though they reduce the fifth to gelatinous flakes or tufts. The fire of the furnace, in half an hour, converts the cryſtals of the ſixth ſpecies into globules of extremely tranſparent glaſs; whereas it only ſoftens, in that time, the minute ſpheres of the fifth, which require a fire of much longer continuance for their complete liquefaction; and the globule, which then reſults, is an opake glaſs, of the colour of milk. Both, however, have the property which is uſually common to zeolites; I mean that of phoſphoreſcence at the moment of fuſion; as may be ſeen by employing oxygenous gas.

After having made theſe experiments on the zeolites of Lipari, I was induced to examine one of thoſe of Iceland, which have the character of being the moſt excellent for forming a gelatinous body. I certainly obtained from it, very readily, an extremely beautiful jelly; but not in the leaſt ſuperior to that produced by the third

and fourth ſpecies. This foreign zeolite is very white, and forms a group of ſmall conical bundles, cloſely conglutinated, and interſecting each other in various directions; terminating, at their diverging extremities, in a multitude of irregular cylindrical needles. In the furnace it becomes inflated and conſiderably lighter, but does not fuſe. With oxygenous gas, a hard, milk-white enamel, full of bubbles, is produced.

If we compare theſe obſervations with the deſcriptions of other naturaliſts, we ſhall find that the zeolites of Lipari have a great reſemblance to thoſe of other countries; and it may be obſerved that the firſt ſpecies is very ſimilar to that of the iſland of Ferro, which Born has deſcribed in his *Lithophylacium*, and which he has compared to the ſtalactical calcedony.

The ſecond ſpecies, from its hardneſs, reſembles ſome cryſtallized zeolites of the Iſles of the Cyclops of Etna, which, as M. Dolomieu

mieu has obſerved, and as I have ſince found by experiment, are little inferior, in that quality, to rock cryſtal.

The three other ſpecies do not eſſentially differ from ſeveral deſcribed by Wallerius, Born, Bergmann, Faujas, and others, and which are found in the iſland of Ferro, the Vivarais, and other volcanized countries. But the ſixth ſpecies appears to me new; at leaſt, I have found no writer who mentions a zeolite, conſtantly cryſtallized with eighteen facets, as often as its cryſtals are detached; nor do I know that any zeolite has hitherto been diſcovered which is equally clear and brilliant.

It appears that the true figure of the zeolite is a cube; at leaſt, that it always affects that form where its cryſtallizations meet with no obſtacles. According to circumſtances it is more or leſs modified; and the tetrahedral priſms of the fourth or fifth ſpecies are probably one of theſe modifications. The firſt and ſecond are amorphous;

but in the third we diſcern a beginning cryſtallization. One of theſe modifications may be ſeen in the ſixth ſpecies; and we know that there are zeolites of other configurations; as ſome with twenty-four facets, and others with thirty.

Some naturaliſts have affirmed that the whiteſt and pureſt zeolite of Ferro is the only one from which a tranſparent and white glaſs can be obtained. I find, however, the glaſs of the ſixth ſpecies preferable to it; for it has an aqueous colour, and its tranſparency is almoſt equal to that of quartzoſe cryſtal. I have found no zeolitic cryſtals, but thoſe of the iſles of the Cyclops, which have furniſhed a glaſs equal to this.

No mineralogiſt is ignorant that Cronſtedt was the firſt who diſtinguiſhed this ſtone from the carbonates of lime with which it was confounded, and made us acquainted with ſeveral of its qualities. He obſerved that mineral acids cauſed no effervescence with it, but ſlowly diſſolved it into a gelatinous

tinous body: and this ſlow diſſolution, and converſion of the zeolite into jelly, was afterwards confirmed by others; though experiments made on newly diſcovered ſpecies of this ſtone have ſhewn that more than one are not, in any manner, affected by acids, even when highly concentrated. From among ſix ſpecies of the zeolites of Lipari, we have ſeen that the third and fourth preſently form, with acids, a tranſparent gelatinous body; which is leſs completely characterized in the firſt and fifth; and not produced at all in the ſecond and ſixth ſpecies.

M. Pelletier has analyſed the zeolite of Ferro, and found that it is compoſed of 20 parts of alumine, 8 of lime, 50 of ſilex, and 22 of phlegm (or impure water). Other analyſes have been made, of other zeolites, by the chemiſts Bergmann, Meyer, and Klaproth. The minute ſize of mine, and, ſtill more, the ſmall quantity I obtained of them, prevented me from making a ſimilar analyſis of them with the requiſite accuracy.

I was,

I was, however, able to aſcertain that the ſecond and ſixth ſpecies contained ſilex in a greater proportion than it was found in the zeolite analyſed by Pelletier; which perhaps was the cauſe that theſe two ſpecies do not form a gelatinous ſediment; the ſuperabundance of quartzoſe earth not permitting the acids to extract the lime and alumine, and thus diſſolve the union of the conſtituent principles of the zeolite.

The gelatinous diſſolution of the zeolite is neither a quality found in every ſpecies, nor is it peculiar to it, ſince experience has ſhewn that it is common to other ſtones, the conſtituent principles of which are the ſame with thoſe of the zeolite, and combined in a certain proportion. This identity of principles, which, in ſome ſpecies of ſtones, affords, by means of the action of acids, the ſame gelatinous product, induced me to make an experiment, of which I ſhall here give the reſult.

The colourleſs garnets of Veſuvius contain,

tain, according to Bergmann, 55 parts of ſilex, 39 of alumine, and 6 of lime. As, therefore, I had collected a conſiderable quantity of theſe at Veſuvius; I determined to make experiments on them with acids, in the ſame manner I had done on the zeolites. But in the three firſt varieties which I poſſeſs, though I had firſt reduced them to powder, no gelatinous ſubſtance was produced. With the fourth I ſucceeded; though I did not make the experiment on the ſame garnets, for the attempt would have been in vain, but on others, of the ſame ſpecies, which I have not mentioned, and which had been greatly ſoftened by the ſulphureous acids, though they retained their four-and-twenty facets. Theſe the nitric acid, after thirteen hours, reduced to a jelly, though not one ſo beautiful as that obtained from the zeolites. We may therefore conclude, that this aptitude to diſſolution was produced in the garnets by the alterations they had ſuffered; in conſequence of which the nitric acid, penetrating their internal parts, had acted on them as it acts in many zeolites.

It

It has been believed that zeolites appertain exclusively to volcanized countries, since they are most frequently found there; and my observations may appear to confirm this opinion. It however admits of no doubt that they are likewise often found in countries that exhibit no signs of volcanization; this having been incontestably proved by Cronstedt, Linnæus, Bergmann and others.

It appears equally certain that the zeolites of volcanos do not derive their origin from fire, but are adventitious to those places; not that they were pre-existent to the volcanic eruptions, and taken up by, and incorporated with, the currents of lava, as a celebrated volcanist has supposed. They were, no doubt, generated after the extinction of the conflagrations; when their constituent parts being deposited by water in the cavities of the lava, and there combining by affinity, formed these stony substances, according to circumstances, sometimes amorphous, and sometimes crystallized; in the same manner that we have

supposed,

ſuppoſed, and, indeed, proved, the beautiful quartzoſe ſtones to be formed in certain lavas on the ſhores of Lipari, not far from Vulcano. The zeolites now deſcribed, likewiſe, afford a proof in favour of this opinion, thoſe, eſpecially, the priſmatic cryſtals of which have for their baſe the ſides of cavities in the lavas.

I ſhall conclude theſe obſervations relative to zeolites, with the following enquiry concerning an hypotheſis adopted by M. Dolomieu.

That naturaliſt was of opinion that the zeolites of volcanized countries are only found in thoſe ſituations which have been covered by the waters of the ſea; and the arguments he adduces to prove this, appear to me ſufficiently convincing with reſpect to the multiform zeolites obſerved by him. But what ſhall we ſay of thoſe we have now deſcribed? I certainly did not neglect to make the moſt accurate reſearches on the ſpot. It has been already ſaid that theſe

ſtones

ſtones are found in the vicinity of the Stoves. The firſt ſpecies is met with about two hundred feet before we arrive at them, on the road from the city of Lipari; the others are ſcattered at a greater diſtance, in the ſteep ſide of the mountain towards the ſouth. One certain proof that theſe places had anciently been waſhed by the ſea, would be the finding of the remains or impreſſions of ſea animals. Thus the above-mentioned French naturaliſt remarks that, at Etna, the lavas of the iſles of the Cyclops, and thoſe of the mountains of Trezza, which abound in zeolites, have certainly been covered by the waters of the ſea, ſince, at the height of more than two hundred perches above theſe zeolitic lavas, immenſe quantities of ſea-ſhells are found. The ſame may, in like manner, be obſerved of the Vicentine volcanic mountains, which afford beautiful zeolites, and alſo copious ſtores of marine remains. It is, however, certain that neither Lipari, nor any of the Eolian iſles, preſent us with any veſtiges of ſea animals or plants. I do not mean to ſay that this is a phyſical demonſtration

demonſtration that theſe places have never been covered by the ſea, ſince it is poſſible that the marine bodies its waters had left, may have been afterwards deſtroyed by cauſes which are not wanting in countries that, at various epochs, have ſuffered the action of fire; I ſhall only obſerve that we are thus deprived of one of the moſt convincing proofs of this ſuppoſed inundation; and I know not on what other we can rely, with reſpect to a country entirely volcanic.

That zeolites derive their origin from water and not from fire, is proved by the water of cryſtallization which is more or leſs abundant in them, and the numbers of them found in ſome provinces of Sweden, which have never been ſubjected to the action of fire. That this water has ſometimes been that of the ſea, the above-cited obſervations of M. Dolomieu will not permit us to doubt; but it has been proved that there are likewiſe inſtances of their having originated from freſh water; of which an obſervation by Bergmann may furniſh an example.

ample. He has remarked that a ſpring of warm water at Laugarnes, in Iceland, when it iſſues bubbling from the earth, leaves no ſediment of any kind, but depoſits it at the bottom of a channel by flowing through which it becomes cooler: and this ſediment is truly zeolitic, as has been proved by chemical examination *. The nature of this fact he ſatisfactorily explains as follows: "While the water is very warm, it holds the zeolitic matter in diſſolution; but, afterwards, becoming cold, can no longer ſupport it, ſo that it precipitates and forms this ſtalactical concretion. This excellent obſervation will account for the frequency of zeolites in many volcanos, ſince the water, whether ſalt or freſh, being ſtrongly heated by the ſubterraneous fires, diſſolves the zeolitic ſubſtances, which it afterwards depoſits within the lava, where they cryſtallize, or remain amorphous, according to circumſtances.

When the traveller has arrived at the ſummit of the Monte della Stufe, he has

* Opuſc. Vol. III.

reached,

reached, in that part, the confines of the iſland; for he ſuddenly perceives the ſea, about four hundred and ſixty feet below him, as near as the eye can meaſure. Taking his way to the ſouth, he, then, diſcovers ſeveral warm ſprings, which ſupply the Baths of Lipari, of equal antiquity with the Stoves, but, like them, now almoſt forſaken; and, proceeding in the ſame direction, meets again with a prodigious quantity of decompoſed lavas, ſimilar to thoſe of the Stoves, exhibiting the ſame varying colours, and coated in different places with cruſts of ſulphate of lime.

When the naturaliſt conſiders, and unites in his mind, theſe prodigious aggregations of decompoſed lavas, which occupy an area of ſeveral miles, he will no doubt be aſtoniſhed to find there is any volcanized country in Europe, in which the ſulphureous vapours, iſſuing from ſubterranean conflagrations, have acted through ſuch an extenſive ſpace. Thoſe of Solfatara di Pozzuolo, which have whitened its crater, and which

are mentioned with a degree of wonder by every writer on that volcano, are certainly inconſiderable indeed, with reſpect to their extent, when compared to theſe. Yet of all the ſulphureous exhalations which muſt have ſpread themſelves ſo widely over the iſland, not one now remains in action, except a few very thin fumes that riſe from the ground near the Stoves.

I viſited the Stoves three times: the two firſt I returned to the city by the ſame road I went, which is hollowed in the tufa; but the third I took my way back by Campo Bianco, and the Monte della Caſtagna, whence I proceeded to the high mountain of San Angelo. We have already ſeen that Campo Bianco and the Monte della Caſtagna are two mountains formed entirely of pumices and glaſſes, that is to ſay, of vitrified ſubſtances *: but how extenſive muſt be the roots of theſe ſubſtances! The declivity of the Monte delle Stufe, and its ample plain covered with tufa, form, as has been ob-

* See Chap. XV.

 ſerved,

ſerved, a bed of pumices, mixed with a great quantity of glaſſes and enamels. At about the diſtance of a quarter of a mile from the Stoves, towards Campo Bianco, the tufa diſappears, and the pumices remain uncovered, forming a continuation with thoſe of Campo Bianco. I have alſo found them in the road near Mount San Angelo, which contains great quantities, and every where they are accompanied with glaſſes. If to theſe we add the other parts of Lipari in which the ſame ſubſtances abound, I ſhall not exaggerate if I ſay that almoſt two thirds of this iſland, which is nineteen miles and a half in circuit, are vitrified.

This immenſe, and almoſt incredible, quantity of vitrifications may, probably, ſuggeſt to the reader the ſame idea which aroſe in my mind when I firſt viewed theſe places: that the fire which has acted on them muſt have been extremely powerful. This idea certainly appears very natural. But ſubſequent experience has taught me that this intenſe heat is not neceſſary for the

production of this great accumulation of vitreous bodies by ſubterranean fires. It is certain that the production of pumices, enamels, and glaſſes requires a greater heat than the ſimple fuſion of lavas, when theſe ſubſtances derive their origin from the ſame baſe; but we ſhall not find it neceſſary that this greater heat ſhould be extremely violent, if we conſider the kinds of ſtones from which theſe vitrified mountains have been produced. The greater part are felt-ſpars, and petroſilex, with ſome ſmall quantities of horn-ſtone. As to the latter, it has already been ſhewn that it eaſily vitrifies in a glaſs furnace with no very vehement fire; in which, likewiſe, many petroſilices and ſome feltſpars are vitrifiable *. It has alſo been ſeen that the glaſſes, pumices, and enamels of Lipari are all completely refuſed in the furnace. It appears to me, likewiſe, that we have poſitive proofs that the volcanic fire was leſs violent than that of the furnace, in the ſubſtances, as well

* See Chap. V. and Chap. XI.

cryſtallized

cryſtallized as amorphous, which, without having ſuffered the leaſt fuſion, are found incorporated in the pumices, glaſſes, and enamels of Lipari, and which may be perfectly liquefied in the furnace.

It cannot, however, be denied that the generative fires of Lipari muſt, at ſome time, have been extremely vehement; ſince, according to the obſervations of M. Dolomieu, they have even fuſed granite, compoſed of quartz, feltſpar, and mica, and converted it into pumice.

The ancient writers have left us very intereſting and inſtructive accounts relative to the ſtate of the conflagrations which in, and prior to, their times had been obſerved in Stromboli and Vulcano; and we have made uſe of them when treating of thoſe two iſlands. But we can ſay nothing of the ancient fires of Saline, and that chain of rocks, which once, probably, made a part of the iſland Euonimos, ſince with reſpect to theſe antiquity is totally ſilent; and we can

only infer that the volcanization of theſe two iſlands was known to the ancients, from a paſſage in Diodorus, who informs us, that all the Eolian iſles were ſubject to great eruptions of fire, and that their craters and mouths were ſtill viſible in his time *. With reſpect to Lipari, very few memorials have been preſerved of its ancient conflagrations. We are indeed certain of the great antiquity of this iſland, and that it exiſted before the Trojan war; ſince we learn from Homer that, after the taking of Troy, Ulyſſes landed there, and was treated with the utmoſt urbanity and courteſy by king Eolus during a whole month, which he continued there †; and though we allow to

* Αυται δε πασαι πυρος εσχηκασιν αναφυσημαλα μεγαλα, ων κρατηρες οι γεγενημενοι και τα σομαλα μεχρι τυ νυν εις φανερα. Lib. V.

† Αιολιην δ' ες νησον αφικομεθ', ενθα δ' εναιεν
Αιολος Ἱπποταδης, φιλος αθανατοισι θεοισι,
Πλωτη εν νησω. Hom. Odyſſ. Lib. X.

Και μεν των ικομεσθα πολιν και δωματα καλα.
Μηνα δε παντα φιλει με, και εξερεινεν εκαστα,
Ιλιου, Αργειων τε νεας, και νοστον Αχαιων. Ibid.

the

the poet the uſual licence of poetry, it is ſtill moſt certain that he could not have named this iſland, and the city it contained, unleſs they exiſted at the time he wrote his poem, ſince which nearly three thouſand years have now elapſed. But if we conſult other ancient and credible writers, we ſhall find that before Eolus, Liparus reigned in this iſland, which from him took its name, being before called *Melogonis*, or, according to others, *Meligunis*.

Another obſervation, likewiſe, here naturally preſents itſelf. An iſland formed by depoſitions, and the ſubſequent retiring of waters, may, in a ſhort time, be cultivated and inhabited; but it is not ſo with one that is produced by ſubterraneous eruptions, where the decompoſition of volcanized matters is neceſſary; that is to ſay, a far longer time. If, therefore, Lipari had inhabitants and cities, and was a cultivated country before the deſtruction of Troy; it is evident that it muſt have exiſted many ages prior to that event.

From the time, however, that mention is firſt made of this iſland in hiſtory to the preſent day, we may conſider it as certain that no true eruption, or current of lava, has taken place in it; as, otherwiſe, it is probable ſome memorial would have been preſerved of it, as well as of thoſe of Stromboli and Vulcano. Ariſtotle, indeed, mentions the fires burning in Lipari, but adds they were only viſible by night*; and the writers who followed him ſay nothing more. I hence infer that this iſland had attained its full formation and ſize, before it was known to men, which was not the caſe with Stromboli and Vulcano. I muſt not omit another obſervation. Many of the lavas of Lipari ſtill ſcarcely exhibit the leaſt ſign of alteration, eſpecially the vitreous, the enamels, and the glaſſes; though it is evident, from what has been ſaid above, that theſe bodies muſt have exiſted above three thouſand years. We hence perceive what

* Και το εν τη Λιπαρα δε πυρ φανερον και φλογωδες, ου μεν ἡμερας, αλλα νυκτος μονον καιεσθαι λεγεται.

In Mirandis.

an

an adamantine temperament, if I may uſe the expreſſion, the fire can beſtow on various ſubſtances, ſince they can thus reſiſt the influence of the ſeaſons and of time.

When I prove the antiquity of Lipari by the authority of Homer, I do not mean to conſider the other neighbouring iſlands as of poſterior date. I am likewiſe well convinced, by the teſtimony of hiſtory, that, except Vulcanello, they were all in exiſtence in the time of that poet, who probably does not mention the other Eolian iſles becauſe Lipari was the largeſt, the moſt fruitful, and moſt generally known, as being the reſidence and ſeat of government of king Eolus.

CHAP.

CHAP. XVII.

FELICUDA.

Two bays in this island capable of receiving small vessels—The products found there by the author, sufficiently prove it volcanic—Circuit of it by sea—Prismatic lavas falling into the sea—Spacious cavern hollowed in one of these lavas—Enquiries relative to its origin—Curious alternation of stratas of tufa and lava—Other prismatic lavas along the shore—Observations relative to them—Excursion into the interior part of the island—A mountain, near the centre, higher than the rest, on which is discoverable the crater of an ancient volcano, to which, probably, Felicuda owes its origin—Conjectures that another smaller volcano existed at the summit of a lower mountain—No other perceivable signs of volcanic mouths throughout the whole island—Qualities of the lavas forming the interior

rior part of Felicuda—Glaſſes, pumices, tufas, and puzzolanas ſcattered over the iſland—Puzzolanas and pumices employed by the inhabitants of Felicuda in building—The ſubſtances of which the iſland is compoſed entirely volcanic, except a piece of granite, which appears to be natural—Reflections on this rock.

IT yet remains to ſpeak of Felicuda and Alicuda, the two extreme iſlands of thoſe of Lipari towards the weſt; and I ſhall the more willingly undertake the deſcription of them, as they have not, to my knowledge, been viſited, at leaſt deſcribed, by any other naturaliſt; M. Dolomieu, who was moſt capable of examining them, having only ſeen them at a diſtance, as to have touched at them would have led him too far from his intended route.

On the 7th of October, in the morning, I ſet ſail from Lipari for Felicuda, diſtant from the former iſland twenty-three miles, and

and arrived there in four hours. This iſland is not provided with a port; but it has two bays, one on the ſouth, and the other on the north-eaſt ſide, ſufficient for the reception of ſmall veſſels, and ſo ſituated, that though the wind ſhould render the entrance into one of them difficult, it will be eaſy to get into the other: both of them are likewiſe ſufficiently ſheltered by a mountain.

I landed in the bay on the north-eaſt ſide, and, in the firſt place, applied myſelf to diſcover of what materials the iſland was formed; and ſoon diſcovered inconteſtable proofs that it is truly volcanic. Not only is the ſhore of this bay lined with lava; but, having in the courſe of the day proceeded farther up on the ſouth-eaſt ſide of the iſland, I found among the earth of ſome fields a conſiderable quantity of pumices, glaſſes, and enamels, which products I ſhall ſeparately deſcribe when I come to treat of the internal part of the iſland.

Being thus fully convinced of the ancient exiſtence

exiſtence of fire in this iſland, I determined, the next day, to make the circuit and examine the ſhores of it, in the ſame manner as I had proceeded in the other iſlands.

Felicuda is nine miles in circumference. I began the circuit of it by examining the lavas that border the ſmall bay which I entered. Theſe have for their baſe the feltſpar, which is of a ſcaly conſiſtence, a light grey colour, not very compact, but giving a few ſparks with ſteel and attracting the magnetic needle. Within its ſubſtance are included needles of black and fibrous ſhoerl, and ſmall pieces of feltſpar, which are eaſily diſtinguiſhable from the baſe by their whiteneſs, ſemitranſparence and luſtre. A part of the ſhores of the bay are compoſed of this lava with deep fiſſures running lengthwiſe, as we ſee in many other lavas. A number of round vacuities are likewiſe obſervable in it. They are of conſiderable depth, and give it the appearance of a honey-comb. I rather incline to aſcribe them to the action of elaſtic gaſeous ſubſtances,

ſtances, when the lava was in a ſtate of fuſion, than to corroſions produced by the influence of the atmoſphere or any external agent. It is certain that the air of the ſea will greatly corrode many foſſil ſubſtances ſituated in its vicinity; and I have witneſſed extraordinary effects from its action on many low rocks, on the ſhore of the Mediterranean, near Genoa, and eſpecially at Porto Venere, the Golfo della Spezia, and at Lerici. I have alſo frequently obſerved the external part of many towers and maritime buildings very much injured on that ſide which fronts the water. The city of Commachio in the territory of Ferrara, perhaps, furniſhes ſome of the moſt complete examples of ſuch effects. It is ſituated in the midſt of ſalt lakes; and its porticos and edifices are ſo much corroded and damaged by the air, that they are obliged to undergo periodical repairs at the end of no very long time, as I obſerved with ſurpriſe during a ſhort ſtay which I made there in October 1792. The ſea air, however, does not act thus on every foſſil ſubſtance indif-

indifferently, but, with reſpect to ſtones, ſeems principally to attack the carbonates of lime; though not all of theſe, as appears from the hard Iſtrian marble with which the ſuperb palaces and ſumptuous edifices of Venice are built, and which remains uninjured for a long ſeries of years. I likewiſe obſerve that volcanic ſtony ſubſtances are little, or not at all, injured by the air of the ſea; and I am the more confirmed in my opinion that the incavations in the litoral lava of which I am now ſpeaking muſt be attributed to the action of aëriform gaſes, and not to that of the ſea air, from obſerving the ſame, likewiſe, in the feltſpar, a ſtone much leſs liable to this kind of alteration than many others.

After having made theſe obſervations, I left the bay, and began to coaſt the iſland towards the left, on the northern ſide. I had ſcarcely proceeded one hundred and fifty paces when I met with a rock of lava, about thirty feet high, and equally broad, riſing almoſt perpendicularly from the water.

This

This rock preſented a novelty I had not before obſerved in the Eolian iſles. This was a number of priſms into which the lava divided before it plunged into the ſea. The importance of this object induced me to bring my boat cloſe under the rock, that I might make the neceſſary obſervations with more certainty and ſecurity.

About twelve feet above the level of the ſea, the rock is ſmooth, and preſents an equal ſurface; but, ſomewhat lower, it begins to be furrowed with narrow longitudinal excavations, which deſcend to the edge of the water, and form priſms with three unequal ſides, the ſide behind remaining attached to the rock, or, to ſpeak more properly, forming one continued whole with it. Theſe priſms continue to preſerve their form under the water, of which I had indubitable proof. The ſea, though then calm, had a ſlight roughneſs towards the rock, to allay which I poured into it ſome olive oil, which I always carried with me in theſe excurſions to calm the leſſer waves of the

the ſea, and thus enable myſelf to perceive ſubaqueous bodies at a certain depth as circumſtances might require. By theſe means I diſcovered that the priſms were immerſed in the ſea to the depth of ſome feet. The breadth of ſome of the priſms was a foot and a half, but that of others leſs.

This priſmatic lava merits to be very accurately deſcribed, ſince, in proſecuting my voyage along the ſhore of Felicuda, I met with it in ſeveral other places, and ſhall again have occaſion to mention it. Its baſe is a horn-ſtone of the black colour of iron, and ſo compact that the ſmalleſt bubble is not perceivable in it; it muſt, therefore, be claſſed among the heavy lavas. The edges of the thinneſt flakes of it are tranſparent, and give ſparks with ſteel. Its fragments are amorphous, and receive a poliſh, but without luſtre. It attracts the magnetic needle at about the diſtance of three lines. The powder of this lava is cineritious, and impalpable, and attaches to the finger. In

it are contained various grains of amorphous feltſpar, and a greater number of ſmall, long, rhomboidal ſhoerls.

The product of this lava in the furnace is a hard enamel, of the colour of pitch, and full of bubbles. The feltſpars it contains remain refractory. It is to be remarked, that this enamel does not loſe the magnetic virtue.

The place where this rock hangs over the ſea is called *Fila di Sacca*. Beyond it the ſhore of the iſland, which continues to have a ſteep deſcent into the ſea, offers only common lavas, except one ſpecies which has ſome rude appearance of priſms, that aſſume a more diſtinct form near the ſurface of the water.

Still farther, at a place called *Saccagne*, a number of ſmall rocks riſe above the ſurface of the water; one of which is called *Il Perciato*, becauſe it is perforated in the middle, and the opening is wide enough to admit

admit ſmall veſſels to paſs through. The forms of priſms are diſtinctly diſcernible in theſe rocks.

At the diſtance of fifty paces farther, a ſpacious cavern opens in the lava of the ſhore; an object highly intereſting and beautiful in the eyes of the volcaniſt. It is called the *Grotta del Bove Marino* (or Grotto of the Sea-ox), perhaps becauſe it was once the retreat of ſome *phoca* or ſeal, as in the Lipari iſlands, and many other places, the phocæ are called ſea-calves. The mouth of this cavern, in the upper part, is oval, and is ſixty feet in breadth, and above forty in height. The mouth opens into a kind of porch, which leads into a ſpacious hall two hundred feet long, or nearly, one hundred and twenty broad, and ſixty-five high. This hall terminates the cavern. The ſea enters it; and as its force is broken by the narrowneſs of the entrance, ſmall barks when ſurpriſed by a ſtorm may there find ſhelter.

Some may perhaps wiſh to enquire, whether the roof of this cavern preſents any of thoſe ſtalactical concretions which are obſervable in many other excavations in mountainous countries. No ſuch concretions are to be ſeen; the ſtone of which it is formed being evidently not of an aqueous but an igneous origin, that is, a lava diſtinguiſhed by the following characters.

Its baſe is ſhoerl in the maſs; it is moderately porous, and therefore rather light; but gives ſparks with ſteel. It is unequal in the fractures, has a ſomewhat argillaceous odour, and attracts the magnetic needle at the diſtance of half a line. It is of a grey colour; but interſperſed with white, ſhining, rhomboidal feltſpars. Their ſplendour is diminiſhed in the furnace; but their whiteneſs appears heightened from the black colour acquired by the enamel produced by the fuſion of the lava, which is opake and extremely full of bubbles. The fuſion, inſtead of diminiſhing or deſtroying, rather increaſes its magnetiſm.

This

This lava, which forms the large cavern, deſcends almoſt perpendicularly into the ſea, and there aſſumes the form of priſms, but larger than thoſe before deſcribed. It is worthy of remark, that theſe priſms, though in their lower part they ſink deep into the water, do not riſe above it, in their upper, more than eight or nine feet.

But in what manner are we to explain the origin of this cavern? How great muſt have been the violence of the waves of the ſea, to form by ſlow corroſion ſo vaſt an excavation within this maſs of lava! To this cauſe I cannot conſent to aſcribe it; principally for this reaſon, among others that might be adduced, but which I omit for brevity, that no ſooner has the water entered the mouth of the cavern but it loſes all its force; beſides that the hardneſs of this lava is ſuch, that it does not eaſily yield to the ſtroke of the waves. I incline rather to think it the effect of the action of the gaſes in the lava at the time it was in a ſtate of fluidity; as we have examples at Etna of

caverns incomparably deeper produced by a ſimilar cauſe.

Immediately beyond the Grotta del Bove Marino, we meet with a mixture of tufa and lava, which merits ſome attention from the curious alternation of its ſtrata. They are found on a high precipice which deſcends into the ſea, the ſurface of which is covered with a tufaceous ſoil, reſting on a bed of lava, above another of tufa, and ſo ſucceſſively, that in a rent made in the precipice by the waters we may number eleven ſtrata or beds of tufa, and as many of interpoſed lava. It appears, therefore, that the fire and water, by their repeated action, have produced this mixture of lavas and tufas.

The lava of the eleven beds is of the ſame kind, that is, of a horn-ſtone baſe, and containing, as uſual, ſhoerls and feltſpars. It has an earthy aſpect, a blackiſh colour, and a ſtrong argillaceous odour. It moves the magnetic needle at the diſtance of two lines,

lines, and the enamel into which it is changed in the furnace has the opacity and blackneſs of pitch, and its magnetiſm is greater than that of the lava before fuſion.

The beds of tufa, likewiſe, do not eſſentially differ from each other. They are an ill-kneaded mixture of lumps of argillaceous earth, more or leſs tinctured with yellow oxyde of iron, which earth is eaſily pulverable. With it are mixed numerous ſhoerls, that from the ſoftneſs of the baſe may be ſeparated entire, which they ſcarcely ever can be in the lava. Notwithſtanding, however, the facility with which they may be detached, it is difficult to determine their cryſtallization, not merely from their extreme minuteneſs, for ſome of them are two lines in length, but from their being ſcarcely ever found ſingle, almoſt every one being a group of aggregated ſhoerls. When one, however, is found ſingle and detached, it appears to be an hexagonal priſm terminated by two trihedral pyramids. They are black, ſhining in the recent fractures, and are ſome-

what fibrous: in fine, they perfectly reſemble in their ſtructure the ſhoerls incorporated in lavas.

The tufa, after remaining two or three hours in the furnace, aſſumes a red colour, and becomes hard; its magnetiſm is likewiſe ſtrong, though before it was ſcarcely perceptible. A longer continuance in the ſame fire reduces it to a porous ſcoria, which does not loſe its magnetiſm, and the black colour it acquires renders more conſpicuous a number of white feltſpars which before were not diſcernible in the tufa. The ſhoerls are ſemi-vitrified, and aſſume a yellowiſh tinge.

In the remainder of my circuit round the iſland, till I returned to the place whence I ſet out, I obſerved no other intereſting objects, excepting a long tract of priſmatic lavas, ſimilar to thoſe I have already deſcribed.

I ſhall conclude what I have to ſay on theſe

theſe priſmatic lavas, which occupy a conſiderable part of the ſhore of the iſland, with the following remarks:

Firſt. Theſe priſms have never more than three faces, one of which always remains adherent to the lava.

Secondly. Their direction is never oblique, or tranſverſe; but, without exception, perpendicular to the ſea.

Thirdly. They are not articulated, as they have been obſerved to be in ſome volcanic countries, eſpecially on Mount Etna, but form one continued line.

Fourthly. In their lower extremity they deſcend within the water, and, in their upper, riſe ſome feet above the level of the ſea.

Fifthly. Theſe priſmatic lavas have for their baſe, either the horn-ſtone or ſhoerl in the maſs.

I ſhall

I ſhall now proceed to deſcribe the objects which appeared to merit notice in the interior part of Felicuda. This iſland, when ſeen from the ſea, at a little diſtance, has the appearance of a number of mountains heaped together; one of which, ſituated in the centre, is much higher than the reſt, riſing, perhaps, half a mile above the level of the ſea. After having examined the baſe or ſhore of the iſland, I proceeded, therefore, to the ſummit of this mountain, taking my way towards the eaſt, as, on that ſide, the road is leaſt difficult. The aſcent is not one of the moſt fatiguing; for though we meet with ſteep precipices in ſome parts of it, they are preſently ſucceeded by gentle declivities, which relieve wearineſs and reſtore ſtrength.

When I had reached the ſummit of the central mountain, I perceived that it incloſed a capacious hollow called *Foſſa delle Felci* (the ditch of fern) becauſe it formerly was overgrown with that plant; though when I was there it had been all rooted up, with the

the intention of ſowing corn the next ſpring. This hollow is about half a mile in circuit, the ſides approach as they deſcend, and its depth is not more than forty feet. Theſe circumſtances ſufficiently prove that this was the ancient crater of the volcano; and that, perhaps, or rather without doubt, this was the firſt, which, by its eructations, contributed to the formation of Felicuda.

It is likewiſe to be obſerved, that the external part of this crater correſponds to the internal; that it is a truncated cone; that its lavas, parting as from a centre, have diverged like rays down the ſides of the mountain, while thoſe on the ſide towards the north-weſt have poured rapidly into the ſea. The propoſal to ſow corn in this hollow argues that it muſt be earthy, as it really is. It is formed of a half pulverulent tufa, under which, however, the lava is diſcoverable.

Three ridges riſe on this mountain, one of

of which deſcends to the ſouth; and, at about half way up, joins another mountain. The ſecond of theſe ridges has its direction to the eaſt, and the third to the weſt. From this ſummit I had a complete view of Felicuda, and looked round me with attention to ſee if I could diſcover the ſigns of any other crater. I thought I could diſcern the veſtiges of one to the ſouth-eaſt, and, afterwards, repairing to the ſpot, was more confirmed in my opinion. I found a hill, about half as high as the mountain already deſcribed, and about two miles in circuit. It is iſolated on every ſide, and has the figure of a broken cone, truncated at the top, where it ſinks into a cavity growing narrower towards the bottom, which appears to be the relics of an ancient crater. Scattered pieces of various lavas, half-buried in an earthy tufa, occupy the cavity of this hill, and its external ſides are formed of a number of currents of lavas.

Except theſe two craters, of the laſt of which I have expreſſed myſelf with ſome doubt,

doubt, I know not of any throughout the whole iſland; as I ſhall not venture poſitively to conſider as ſuch a number of cavities, hollows and caverns which we meet with in various places, ſuch appearances not being ſufficient to characteriſe a volcanic mouth.

The principal lavas of the ſhore of Felicuda have already been deſcribed ſingly: it is now neceſſary to ſpecify thoſe which form the internal and more elevated parts of the iſland. Theſe, as far as I was able to diſcover, during the ſtay of five days which I made there, may be reduced to three kinds, if we omit thoſe which are merely varieties.

The baſe of the firſt is a horn-ſtone of a colour between a black and a grey, of a fracture evidently brilliant, without any appearance of pores, and which gives ſparks copiouſly with ſteel. The pieces into which it breaks have no determinate form, do not refuſe a tolerable poliſh, and move the magnetic

netic needle at the diſtance of a line and three-fourths. Minute grains of quartz, numerous ſcales of feltſpar, and extremely ſmall and brilliant needles of ſhoerl are incorporated in this lava.

The furnace fuſes the ſhoerls, but not the quartz, and the feltſpars; and the lava is changed into a black, frothy, and opake enamel.

This lava extremely reſembles the priſmatic lava deſcribed above; though it has not that regular configuration.

The lava of the ſecond ſpecies is likewiſe of the horn-ſtone baſe; not very hard nor heavy; of a cinereous and earthy aſpect, without pores, attaches ſlightly to the inſide of the lip, and emits an argillaceous odour. The ſhoerls it contains are rhomboidal, ſcaly, and of a violet colour.

In the furnace it is only ſoftened; and the ſhoerls remain entire.

The third ſpecies has for its baſe, ſhoerl in the maſs. It is black, without pores, rather heavy, and of a granular fracture.

The heterogeneous ſtones, which are mixed with the ſubſtance of this lava, are of three kinds: ſmall irregular quartzoſe particles, which, from their whiteneſs, are moſt conſpicuous; a few minute feltſpars; and numerous rhomboidal ſhoerls, of a dark violet colour, and remarkable for their ſize, ſome of them extending to ſeven lines.

The feltſpars and quartzoſe grains are refractory in the furnace; though their baſe is eaſily fuſible, and produces a ſhining, opake, and porous enamel.

The internal part of the iſland, as far, at leaſt, as appears from the ſurface, is compoſed of theſe three lavas and their varieties; which lavas form currents, that, from their great antiquity, do not exhibit thoſe tumours, wavings, and inequalities, which are obſervable in recent lavas, or thoſe of a moderate

derate age. The ſame antiquity is, likewiſe, probably the reaſon, why in Felicuda we do not find ſcoriæ, or ſcoriaceous lavas; theſe, uſually, from their ſlight and feeble texture, and from their lying on the ſurface of the current, being the firſt which are altered and deſtroyed.

When treating of Lipari, I remarked the great effects which have been produced on the products of that iſland by the ſulphureous-acid exhalations. The contrary is to be obſerved of Felicuda, there not being a ſingle lava which exhibits the leaſt ſign of their influence; though they all bear the marks of the injuries of time and of the atmoſphere. So much have I found them changed, eſpecially near the ſurface, that had I not broken up the lavas to the depth of ſome feet, a practice to which I had accuſtomed myſelf in theſe reſearches, I ſhould frequently have taken the ſame lava for others ſpecifically different.

Having thus deſcribed the different kinds of

of lavas of this iſland, it will now be proper to proceed to treat of the other volcanic ſubſtances it contains. Among theſe are the tufas, which are found in great abundance in other parts of the iſland beſide thoſe above deſcribed. In general they are pulverulent, light, ſpungy, of an argillaceous nature, and greedily imbibe water. The places in which they are found, are the only parts of the iſland which the inhabitants can render productive by cultivation.

It is among the tufas that we diſcover glaſſes and pumices. We will treat of theſe two ſubſtances ſeparately, beginning with the firſt.

I have already ſaid, that I had ſcarcely landed in Felicuda before I diſcovered ſeveral pieces of volcanic glaſs. In my ſubſequent reſearches, I afterwards diſcovered that this glaſs was not found among the lavas, but in the cultivated earth of the fields. The peaſants of thoſe parts confirmed the truth of this obſervation, and, finding I was

in ſearch of this ſubſtance, brought me more of it than was neceſſary, which they collected in the fields where they worked. As I was not, however, perfectly ſatisfied with this firſt obſervation, I directed them to dig a deep trench in one of the fields which moſt abounded in ſpecimens of this ſubſtance, with a view to try if I could diſcover a vein, theſe being only detached pieces. The trench they dug was eight feet deep, and five in breadth. For the depth of two feet I found only a tufaceous earth, containing ſome of theſe vitreous pieces. At a greater depth the virgin tufa appeared, untouched by the ploughſhare, or any ruſtic inſtrument. This tufa likewiſe furniſhed a ſimilar glaſs, but always in detached pieces; nor was any difference perceivable in the nature of theſe products, on continuing the reſearch to the bottom of the trench, where the tufa was ſtill found.

It appears, therefore, that the glaſs in the ploughed fields had its ſeat in the tufa; though it cannot be affirmed with certainty, that

that it was thrown out from the mouth of the volcano in the ſame ſtate in which it is now ſeen; ſince it is only found in plates or flakes, and with thoſe points and ſharp angles, thoſe cutting edges and waving ſtreaks, which we obſerve in glaſs, whether volcanic or factitious, when it has been broken and divided into fragments by a hammer, or other heavy body. We muſt therefore conclude, that after the ſubterranean conflagrations had reduced the ſtony ſubſtance to glaſs, this glaſs has been thus broken and ſhivered by ſome convulſion of the earth, or by ſome violent and tumultuary agent.

The larger pieces are about five inches and a half over, and two in thickneſs. Many of them are not inferior in clearneſs and brilliancy to the fineſt and brighteſt glaſſes of Lipari; others are leſs tranſparent, and of a cineritious, or grey, colour; while others are almoſt entirely opake; and theſe approach nearer to the nature of enamels than to that of glaſſes. They are all, how-

ever, extremely compact, and will readily give ſparks with ſteel, and cut common artificial glaſs. Several of theſe pieces contain within them ſmall white particles, which have been obſerved and deſcribed in many of the glaſſes of Lipari, which particles indicate that the glaſs containing them is not ſo perfectly vitrified as the reſt. We alſo find pieces, though they are rare, the one half of which is a very black glaſs, and the other a ſimple lava. The lava, which thus forms a whole with the glaſs, is of a cineritious colour, and, as appears from ſome analyſes which I have made of it, is of a petroſiliceous baſe.

This glaſs, like other volcanic glaſſes, changes in the furnace into a vitreous froth.

It now remains to ſpeak of the pumices, which are likewiſe enveloped in theſe tufas. Theſe never form large maſſes, but are always found in detached pieces, of rather a ſmall ſize, the largeſt rarely exceeding the bigneſs of the cloſed hand. In general they

are

are more plentiful than the glaſſes, and among the tufas of uncultivated places, it is only neceſſary to remove the ſurface to find them by hundreds. During my ſtay at Felicuda I reſided in a place called La Valle della Chieſa (the Valley of the Church). This is a ſmall plain, on the eaſt ſide of the iſland, in which ſtand the parſonage-houſe and the church, two indifferent buildings, ſuitable to the poverty of the country. This place, as likewiſe a ſpacious declivity to the ſouth, abounded with pumices, both on the ſurface of the tufas, and below the ſurface, wherever they were dug into.

Theſe pumices are of two kinds; the one cellular, extremely friable, fibrous, and which float on the water; and the other compact, heavy, without pores, and of a ſmooth fracture; but which yet poſſeſs all the true characters of pumice. Some are of a reddiſh colour, others yellowiſh, and many aſh-grey. All are plentifully furniſhed with extremely brilliant vitreous felt-ſpar-ſcales.

In my obſervations on the pumices of Vulcano I have remarked, that inſtead of ſwelling in the furnace, and being tranſformed into an ebullient product, as is almoſt always the caſe with glaſſes and compact enamels, they become of leſs bulk, loſe their pores, if they had any before, or, at leaſt, contract, and therefore become heavier. The preſent pumices do not differ in this reſpect from thoſe of Vulcano; and the enamel which they produce in the furnace has a black and ſhining ground, interſperſed with whitiſh ſpots, which are feltſpars that, having loſt their luſtre and tranſparency, are become white. This enamel puts the magnetic needle in motion at the diſtance of a full line, notwithſtanding that it had no ſenſible effect on it when in the ſtate of pumice.

There is no reaſon to ſuppoſe that theſe pumices have ever formed currents, both becauſe they are always found in detached pieces, and becauſe their pores have not that direction which is uſually obſervable in pumices

pumices that have flowed in the manner of lavas. The figure of the pores in pumices that have flowed, is uſually more or leſs oblong; whereas in the pumices of Felicuda (I mean the cellular) the pores are almoſt always orbicular. We muſt therefore conclude that they have been thrown out from the mouths of volcanoes; to which the globoſe figure of many of them is perfectly conſonant.

I ſhould eſteem my account of the different productions of this iſland very defective, were I not to mention another which ſtill more confirms its volcanization: I mean the puzzolana found here in ſeveral places, and which, when carefully examined, is found to be a mixture of minute fragments of pumices, tufas, and lavas. The inhabitants of Felicuda make uſe of it, as alſo the pumice, in building their houſes; in the following manner. They bring carbonates of lime (calcareous earths) from Sicily; and burn them in furnaces, which are erected, for greater convenience, on the

ſea-ſhore; and at the end of forty hours an excellent lime is produced. One-third of this and two-thirds of puzzolana, mixed together with water, form a cement which unites and binds the pieces of lava here uſed inſtead of bricks and ſtones; and to give, as they affirm, a greater ſtrength and ſolidity to the cement, they mix with it pounded pumice of their own country.

Lavas are uſed as materials for the building of houſes, not only by the inhabitants of Felicuda, but by thoſe of all the other Eolian iſles, each uſing thoſe of their own iſland; and it is the practice, not only in the country but even in cities, to build with ſuch ſtones as the environs afford, eſpecially when they are mountainous. I therefore, wherever I went, conſtantly examined the materials of which the villages, towns, and cities through which I paſſed were built; which frequently afforded me a light and direction in my enquiries relative to the foſſil ſubſtances of thoſe countries.

On

On reviewing the different volcanic bodies which I met with at Felicuda, we ſhall find that they conſiſt of glaſſes, pumices, tufas, puzzolana, and lavas with a baſe of ſhoerl, feltſpar in the maſs, or horn-ſtone. The iſland at preſent exhibits no indication of ſubterranean fire, and even thoſe ſigns which are uncertain and equivocal are wanting; ſuch, for inſtance, as warm ſprings.

In the various excurſions I made, I was particularly attentive to obſerve if by accident I ſhould meet with any body not volcanized; and found one only of this deſcription. This was a piece of detached granite, lying on the ſhore near the Grotta del Bove Marino. Its elements were of the moſt common kind; mica, feltſpar, and quartz. The mica was partly black, and partly white and ſilvery; both forming groups in which the black predominated. The quartz was in ſmall ſemi-tranſparent maſſes, of a vitreous and brilliant fracture, ſoft to the touch, and of a colour between a blue and a white. The feltſpar, which in quantity exceeded

exceeded the two other principles, and therefore muſt be conſidered as the baſe of the ſtone, was in ſmall maſſes of unequal ſurface, lamellar in the fractures, tranſparent in the angles, and of a changeable milky whiteneſs. Neither of the three principles has a determinate form of cryſtallization. I think I ſhall not be miſtaken if I aſſert, that this granite has not ſuffered the action of the fire. In fact, a continuance of a quarter of an hour in the furnace produced in it ſo great an alteration, that every part of it was ſenſibly changed. The mica became pulverable, the quartz extremely friable and full of cracks, and, loſing its tranſparency and vitreous brilliancy, became entirely white. The felt-ſpar, likewiſe, contracted a conſiderable friability; loſing at the ſame time its changeable colour, and becoming whiter. It is not therefore extraordinary that a ſlight blow with a hammer ſhould now break this ſtone into ſmall pieces; though before it would only ſtrike off, at moſt, a ſingle fragment. When expoſed to the furnace for ſeveral days ſucceſſively, the quartz and mica did

not

not fuſe; and the feltſpar only exhibited, at the angles, a beginning of fuſion, which made it appear as it were unctuous. This experiment is perfectly agreeable to many others which I made in the furnace on the granites treated of in Chap. XII. We muſt therefore conclude, that this piece of granite was thrown out untouched from ſome volcano in the iſland; or, which appears more probable, that it is adventitious to it; for it is to be obſerved, that it was not found in the interior part of the iſland, but on the beach, where it had been beaten, and had its corners ſmoothed by the waves. Were I to indulge conjecture, I ſhould incline to ſuppoſe it might have been brought by the ſea from Capo Melazzo in Sicily, or that vicinity, which is only fifty-four miles diſtant from Felicuda, and where immenſe maſſes of ſimilar granite are found*.

* See Chap. XII.

CHAP. XVIII.

ALICUDA.

Danger to which the author was expoſed, in a tempeſt, on his paſſage from Felicuda to Alicuda—Pumices and glaſſes found in the latter iſland—Examination of the coaſt of Alicuda—Several rocks formed of detached globes of lava—Enquiries relative to the origin of theſe globes—Confirmation of the uncertainty of any opinions formed relative to the greater or leſs antiquity of lavas, from the more or leſs ſenſible decompoſition they may have undergone—Iſolated maſſes of porphyry, which exhibit no ſigns of having been attacked by volcanic fire—Lavas of another kind—Shoerls of a greeniſh blue colour contained in all theſe lavas—The coaſt of Alicuda more rugged and threatening than that of any other of the Eolian iſles—No mouth of any ancient crater in the ſides of the iſland—The

—The appearance of a true crater found only at the ſummit—Lavas in the interior part of the iſland ſimilar to thoſe of the ſhores—Improbability that Felicuda and Alicuda once formed a ſingle conical mountain, the ſide of which has been opened and ſeparated by the ſea, as M. Dolomieu has ſuppoſed—Reaſons for believing that each was originally a ſeparate iſland—Theſe two iſlands no longer manifeſt any ſigns of actual fire—The ſilence of the ancients relative to their fiery eruptions, a proof that they muſt have long ceaſed to burn.

ON the 13th of October, at ſun-riſe, I left Felicuda, in a ſmall bark, with four rowers, which was ſteered by the pariſh-prieſt of Felicuda, who had the character of a ſkilful ſeaman. We ſailed before a moderate eaſt-wind: the ſky was clear, the ſea ſmooth, and we flattered ourſelves we ſhould ſoon reach the place of our deſtination, as the diſtance between theſe two ſmall iſlands is not more than ten miles. But ſcarcely were we half way, when the wind began to in-

creaſe

creaſe ſo that we were obliged to reef our ſail, which it was dangerous to carry full; yet ſtill we made more way than before; and the wind blowing with greater violence, and driving us rapidly towards Alicuda, from which we were now not far diſtant, endangered our being ſhipwrecked on the ſhore. Bays or harbours are things unknown in this iſland, and our bark driving before the wind, it was to be feared, might ſoon daſh againſt a rock, or run upon a ſand-bank; and we had the leſs hope of being able to avoid this danger, as our ſailors, from unpardonable negligence, had not brought with them any anchor.

The ſea, in the mean time, ran very high; and the waves, which would not, perhaps, have given much alarm to a large ſhip, were very formidable to our little veſſel, which they broke over from ſide to ſide, and from ſtern to prow, whirling it round with their violence; while the danger of being wrecked continually increaſed by our approaching the iſland, notwithſtanding all the exertions we

we could make with our oars to keep off it. Our ſailors, however, did not entirely abandon themſelves to deſpair, but conſulted whether it would be leſs dangerous to yield to the violence of the waves, and endeavour to run the bark on ſome ſand-bank joining to the ſhore; or, avoiding the iſland, to adventure out to ſea, and commit themſelves to the mercy of the winds.

In this deſperate ſituation, we perceived five men haſtily deſcending from the eminences of Alicuda, and approaching the ſhore, which they quickly reached; when one of them called to us in a voice which might be diſtinctly heard notwithſtanding the noiſe of the waves, adviſing us not to be terrified, but to endeavour to keep where we were, and he would exert his utmoſt efforts to deliver us from the danger by which we were threatened.

This perſon, as I afterwards found, was the pariſh-prieſt of Alicuda, who perceiving, from a diſtance, the ſituation in which

we

we were, had haſtened, with four of the iſlanders, to give us aſſiſtance. He had brought with him a ſtrong pulley, which, when fixed on the ſhore, was to receive a rope, by means of which the veſſel might be drawn upon the land. But to effect this, it was neceſſary to form a kind of inclined plane on the ſhore, along which the boat might be drawn; which was ſoon done, with the ſpades and ſhovels that had been provided for the purpoſe.

We were not more than fifteen feet from the land, and, by inceſſantly plying our oars, made every effort to avoid approaching it nearer. We were obliged, at the ſame time, continually to bale the water out of the boat, to prevent its ſinking; which was the continual employment of myſelf and my ſervant, the ſailors being entirely occupied in uſing the oars. A rope coiled up was now thrown on ſhore by one of the ſailors, and, after two or three unſucceſsful attempts, caught by the perſons on the beach and paſſed through the pulley; while the

ſailor drew it tight, and faſtened it to the prow of the bark. We now committed ourſelves to the firſt wave that rolled upon the ſhore; and, the five iſlanders pulling the rope with all their force, we were drawn with the bark up the ſhelving declivity they had made: but the wave on its return, daſhing impetuouſly againſt the prow, drove us again into the ſea; and ſo violent was the ſhock, that the rope broke, and we loſt all hope of getting ſafe on ſhore. At this unfortunate and unexpected accident the good prieſt ſtruck his hand againſt his forehead, from vexation and diſappointment, and our conſternation was extreme.

We had now reſolved to keep off from the iſland, and brave the fury of the winds and the waves, in the open ſea, whatever might be the event: but from this we were diſſuaded by theſe iſlanders, who aſſured us it was impoſſible ſo ſmall and crazy a boat as ours ſhould long reſiſt the violence of the ſtorm in the wide ſea; but that it muſt either overſet, or bilge and ſink. They adviſed

us rather to coaſt the iſland towards the north, where we might poſſibly find ſome ſmall inlet, where we might be leſs expoſed to the waves; promiſing us that they would proceed the ſame way along the ſhore, and afford us every aſſiſtance in their power. This advice we followed, and, bearing up to the north, without ſtanding far from the ſhore, in about half an hour met with a cavity in a rock, which, from being winding, was not much expoſed to the agitation of the waves. Into this we happily carried our bark without damage, and landed, with the aſſiſtance of the worthy prieſt and the perſons with him, towards whom I ſhall feel the warmeſt ſenſations of gratitude while life ſhall remain. He treated us, when on ſhore, with the utmoſt kindneſs and hoſpitality; and when I had preſented to him the circular letter I had received from the Biſhop of Lipari (in which I was warmly recommended to the pariſh-prieſts of thoſe iſlands, who were requeſted to furniſh me with every aſſiſtance neceſſary for my philoſophical reſearches during my ſtay), he redoubled

his

his civility, offering to ſerve me in every manner in his power; and his whole conduct ſufficiently evinced the ſincerity of his offers.

It was not yet noon, by ſome hours, when we landed in Alicuda, but the fatigue I had undergone prevented my having any inclination to begin my reſearches that day; and the following night I ſlept in the bark, which had been drawn on ſhore; my deliverer (for ſo I may juſtly call the good prieſt of this iſland) having ſent me a mattreſs, and a coverlet, to defend me from the moiſture of the night, as I was too much fatigued to aſcend to his habitation, which was ſituated half way up the mountainous iſland. He likewiſe hoſpitably invited me to ſhare with him the proviſions of his frugal table, and ſome bottles of excellent malmſey of Lipari, which revived my ſpirits, and reſtored my ſtrength.

I remained at Alicuda two days (the 14th

and 15th of October), during which I ſufficiently gratified my curioſity, and acquired a ſatisfactory knowledge of the nature of the iſland. The obſervation of the ancient Grecian philoſopher is well known, who having been driven by a tempeſt on the coaſt of Rhodes, and with great difficulty reached the land, ſeeing certain geometrical figures traced in the ſands, immediately exclaimed: *I perceive the veſtiges of men:* I, in like manner, the moment I ſet foot on the ſhore of Alicuda and ſurveyed it, might have exclaimed: *I perceive the veſtiges of fire.* Theſe were the pumices, glaſſes, and enamels, which preſented themſelves to my view on the ſkirts and ſides of Alicuda, and which it is unneceſſary particularly to deſcribe, ſince they entirely reſemble thoſe of Felicuda, and are found like them mingled with tufaceous ſubſtances.

Of the two days which I allotted to my reſearches in Alicuda, I ſet apart the firſt to examine its circumference by ſea, the night preceding

preceding the 14th of October having been ſufficiently calm to permit me to make the circuit of it in my boat without danger.

I ſhall here, therefore, ſpecify the principal products I diſcovered during my circuit round the ſhore of the iſland; this being the part which, more than any other, muſt intereſt the philoſophical naturaliſt. I ſhall not name the places where I found them, ſince two of the inhabitants who accompanied me were unable to aſſign any names by which they were known; the different parts of the ſhore of the iſland having in fact no fixed names: I ſhall only indicate their diſtances from the place whence I ſet out.

At the diſtance of forty paces from that part of the iſland which fronts the eaſt, we begin to find, as we turn towards the north, entire rocks, formed of globes of a blackiſh lava, with a petroſiliceous baſe, which, though porous, is heavy from the compactneſs of the ſolid parts, which have a little

luſtre, are very hard, and in their fractures affect the conchoidal figure; they move the magnetic needle at the diſtance of more than a line, and give ſparks tolerably freely with ſteel. The petroſiliceous ſubſtance contains a few feltſpars, and a conſiderable number of ſhoerls. Theſe globes of lava are of various ſizes, ſome of them being a foot in diameter. They are detached, and are never found in ſtrata, but only in large accumulated heaps.

To what cauſe can we aſcribe the diviſion of this lava, and its conformation in the manner deſcribed? I at firſt imagined that its figure might be the conſequence of the agitation of the ſea, when its waters reached to a greater height; as theſe accumulations of globes are now ſome poles above its level. In fact, in my maritime excurſions round the other Eolian iſles, and at Etna, I have frequently met occaſionally with ſimilar balls of lava, which clearly indicated that they had been rounded by being continually rolled by the waves of the ſea, in the ſame manner

manner as we find ſtones rounded in rivers. In the courſe of this work I have adduced ſeveral examples of this kind, even among the glaſſes and enamels of Lipari, which have taken a globoſe figure. But a more careful examination of theſe globes compelled me to change my opinion, on conſidering that the pieces of lava that have acquired an orbicular form from the agitation of the waters, are always more or leſs ſmooth on their ſurface; whereas theſe were rough all round—though their roughneſs, conſiſting in general of minute parts and points, muſt have been worn away by rubbing againſt any obſtacle. I obſerved, beſides, that theſe globes, in many places, had a ſhining and ſcoriaceous appearance, extremely ſimilar to that of the pieces of lava inceſſantly thrown out by the volcano of Stromboli. I am therefore rather of opinion that they are pieces of lava that have been thrown out from a volcano in Alicuda, and taken a ſpherical form in the air, from their great ſoftneſs, as ſimilar phenomena may be

obſerved in the products of other burning mountains.

About a mile and a half beyond the lava now deſcribed, proceeding ſtill towards the north, we find a ſecond, not in globes, but in an ample current, which falls like a cataract into the ſea. It is of a petroſiliceous baſe, has the colour of iron, is ſiliceous, or rather vitreous in the fracture, and full of ſhoerlaceous cryſtallizations. Whoever has ſeen lavas which have lately iſſued from the mouth of a volcano, would imagine this of extremely recent date. On the ſurface, it preſerves that ſhining aſpect, that freſhneſs, which is peculiar to lavas that have not yet been expoſed to the influences of the atmoſphere. The ſpecimens of it which I detached, might be taken for that ſcoria of iron which we find in the ſhops where that metal is fabricated. I have in my poſſeſſion ſome pieces of the lava which was thrown from the higheſt crater of Etna, in 1787, which I collected on the ſpot, and have deſcribed

ſcribed elſewhere *. Theſe, with reſpect to the freſhneſs of their appearance, are not diſtinguiſhable from the lava of which I now ſpeak. Yet is the latter of an antiquity beyond our knowledge, for we have no record of any conflagration in Alicuda ſince hiſtory has been written. I have choſen to ſpeak more at length on this peculiar property of the preſent lava, to prove, or rather to confirm what I have already proved, how uncertain are all concluſions relative to the greater or leſs antiquity of lavas, derived from the more or leſs ſenſible degree of decompoſition which they manifeſt. Such concluſions may be well founded, when the lavas are of the ſame nature, and affected by the ſame extrinſic circumſtances; ſince, then, thoſe of a more ancient date muſt be moſt changed by time: but where their nature and qualities are different, one lava may be conſiderably altered in a few years, and even reduced to an earth, while another ſhall remain for ages, perfectly

* See Chap. VIII.

preſerved,

preſerved, and in the ſame ſtate in which it was thrown out of the fire, of which the lava now deſcribed is an evident example.

At the diſtance of another full mile from the place whence I took my departure, the mountainous coaſt of the iſland becomes ſomewhat more level; and on this plain ariſe detached maſſes of porphyry, which ſhew no ſigns of having been touched, much leſs fuſed, by the fire. It is of a petroſiliceous baſe, of the colour of brick, affords ſparks with ſteel, and is extremely compact, and without pores, except a few ſuperficial vacuities, coated with a thin white cruſt of carbonate of lime, ſometimes ſtudded with cryſtals of the ſame kind. Theſe ſmall geodes, which have been produced, without doubt, by filtration, are decompoſed in a few moments by the nitric acid, and diſſolve with a ſtrong effervescence. This porphyry, in its hardneſs, poliſh and luſtre, is not inferior to the Egyptian. Beſides ſhoerls, it contains numerous cubical

cubical lamellar feltſpars, of a changeable whiteneſs.

When expoſed to the furnace for a few hours it becomes black, and after a longer time fuſes into a black, compact, and very ſmooth enamel, which ſets in motion the magnetic needle, though it produced no ſuch effect when it was porphyry. The feltſpars remain entire.

In this part of my circuit round Alicuda I have deſcribed two kinds of lavas, the one found in detached globes, and the other in a current; which, however, from the identity of their nature, may be conſidered as one only; both having for their baſe the petroſilex, and containing ſhoerls and feltſpars: they are therefore both porphyritic. And as the rock laſt deſcribed is a porphyry with a petroſiliceous baſe, it appears that they all three derive their origin from one common matrix, except that one portion of it has been ſubjected to fuſion, and the other remained untouched.

A little

A little beyond the plain abovementioned appear ſome tufas, which cover a long and ſteep declivity deſcending into the ſea, and beyond the tufas we again meet with lavas forming broad currents. Theſe lavas have the horn-ſtone for their baſe, and their external characteriſtics are the following:

They are light, extremely porous, and therefore eaſily penetrable by water; they with difficulty give ſparks with ſteel, which breaks off fragments at every ſtroke. They feel rough under the finger, and emit an argillaceous odour. They contain numerous feltſpars, which are conſpicuous from their whiteneſs, on a dark red ground approaching to a black. Some ſhew a degree of calcination which they have ſuffered in the fire, and are, in conſequence, eaſily crumbled. Others have ſuffered no injury; and the difference obſervable in them is rather to be aſcribed to the difference of the nature of the feltſpars, than to their having ſuffered a greater degree of heat, the lava in which they are both incorporated

appearing

appearing to have been equally affected by that agent.

Alicuda is about ſix miles in circuit, and I have as yet made the tour of only the one half. On completing it, however, I only met with lavas of the ſame kind with thoſe already deſcribed, diverſified by a few varieties that do not merit a particular deſcription.

I have given ſome faint ſketches of the appearance of the lavas in ſome parts of this iſland; but it would be impoſſible for me to give an adequate idea of the fearful wildneſs of the ſcenes which preſent themſelves to the eye for two-thirds of this circuit. Among all the volcanized places I have viſited, I have yet ſeen none ſo convulſed by ſubterranean fires, ſo torn and ſhattered, and ſo filled with accumulated ruins by the devaſtations of time and the ſea.

In ſome places we find a lava extending for

for ſeveral hundred paces, which has been broken by the waves in ſuch a manner as to form a rock ſurrounded by the water, abounding in craggy cliffs and precipices of a fearful height.

In others the lava deſcends perpendicularly from the moſt elevated ſummit of the mountain, and buries itſelf in the water, ſurrounded on the ſides by projecting crags, and huge overhanging ſtones, which threaten every moment to thunder down into the deep.

Here the lavas do not form one continued body, but are compoſed of detached and looſe globes, particularly dangerous to thoſe who may attempt to aſcend the mountain, as they roll from under and put in motion a great number of others, thus producing a deſtructive ſtony torrent. Even the large falcons, which frequent the higheſt ſummits of this iſland, if they chance to alight on theſe heaps of round, looſe ſtones, will often, as I have myſelf ſeen, by moving

one, put others in motion, till bird and ſtones fall, all together, headlong into the ſea.

In another place lavas are found, not of one kind alone, but a confuſed mixture of ſeveral, piled in diſorder one on another to a prodigious height; and in many of them there is no part which does not threaten immediate fall and ruin.

Through the midſt, however, of theſe miſhapen rocks and horrid precipices are formed, I will not ſay roads or paths, but narrow winding gutters, by which we may aſcend to a certain height; and throughtheſe I took my way, when from time to time I landed from my boat and went in ſearch of the lavas I have deſcribed, and examined them on the ſpot. I was obliged, however, to advance with the greateſt caution, as to have made a ſingle falſe ſtep would have been to have fallen headlong down a precipice. I could not but recollect the lines of Dante, in which he deſcribes the laborious

borious paſſage over the horrid crags and precipices of one of the abyſſes of his Hell.

" E proſequendo la ſolinga via
Fra le ſchegge, e tra rocchi de lo ſcoglio,
Lo piè ſenza la man non ſi ſpedia."

" And ſtill along the ſolitary way,
" Proceeding over rocks and precipices,
" The foot without the hand no progreſs made."

And though the fatigue in again deſcending to the ſea might be leſs, the danger was equal, if not greater, from the unſtable and ſlippery nature of theſe deceitful places.

Having completed the circuit of the ſhores of Alicuda on the fourteenth of October, I appropriated the next day to the examination of the interior part of the iſland. I could, however, only make my reſearches in the part which fronts the eaſt and ſouth-eaſt; the remainder being inacceſſible from the dreadful crags and precipices already mentioned.

When

When ſeen from the ſea, on the ſouth-eaſt ſide, at the diſtance of two or three miles, this iſland has the appearance of an obtuſe cone, but with a conſiderable incavation on one ſide. This incavation has no reſemblance to a crater, and on a nearer examination we find it is only a lower part of the mountain. In fact, we perceive no marks of the mouths of ancient volcanos in the whole circuit of Alicuda; either becauſe they have never exiſted there, or becauſe all traces of them have been effaced by time or ſome other deſtructive agent. I have diſcovered the appearances of a true crater no where but in the higheſt part of the iſland, where there is a hollow, not very deep indeed, but about half a mile in circumference; and I incline to believe it to have been a crater, from finding there a group of lava diverging as from a centre over the body of the iſland.

I examined the lavas which cover the ſides of this mountainous iſland, at leaſt where I could reach them without danger,

in the ſame manner that I did thoſe which form the baſe or ſhore of it. I ſhall not deſcribe them particularly, as it appears unneceſſary, they generally having the petroſilex or horn-ſtone for their baſe, and abounding more or leſs, as uſual, in feltſpars. Their external ſurface is covered with a yellowiſh and friable coating, originating in a beginning decompoſition. The deep fractures which we find in many parts of them enabled me to perceive that they muſt have flowed at different periods, forming beds or ſtrata one above the other, as is frequently obſerved in other volcanized countries.

M. Dolomieu was of opinion that "Fe-
"licuda and Alicuda had once formed a
"ſingle conical mountain, which had been
"opened and ſeparated on one ſide."

This is certainly not impoſſible, but I muſt ſay it appears to me extremely improbable. If the ſea, or any other violent agent, had divided this conical mountain into

into two parts, it is difficult to conceive that no record or tradition ſhould remain of this convulſive ſeparation. On the contrary, when I attentively examine and conſider theſe two iſlands, they have every appearance of being each a diſtinct iſland, like Stromboli, Saline, and the others. Both likewiſe have on their higheſt ſummits the veſtiges of their primitive crater, that is, of that which by its eructations has given birth to its reſpective iſland. The lavas, likewiſe, which have flowed from theſe ſummits, as from central points, and enlarge and extend as they take their courſe down the ſides of the mountain towards the ſea, ſeem clearly to prove that each was a complete iſland in itſelf; nor can I doubt but the French naturaliſt, had he viſited theſe iſlands themſelves, would have been of my opinion. He only viewed them from the higheſt part of Saline, that is, at the diſtance of five-and-twenty miles from Felicuda, and five-and-thirty from Alicuda. At that diſtance they ſeem very near to each other; ſo that M. Dolomieu, judging from appearance, ſuppoſes Felicuda

to be only five miles from Alicuda, though it is in reality twice that number. As, therefore, at Saline, they appear to be ſo little diſtant from each other, nothing was more eaſy than to imagine that they once formed a ſingle mountain, which, either by earthquakes, the violence of the ſea, or ſome other unknown cauſe, had been broken and divided into two parts, an arm of the ſea taking poſſeſſion of the intermediate ſpace.

From the ſummit of Saline he, likewiſe, eſtimated Alicuda to be only twenty miles from Cefalu, on the coaſt of Sicily; and, in fact, when I was on the ſame eminence, theſe two places appeared to me to be very near, and Felicuda ſeemed almoſt to join to Alicuda; yet it is certain that the diſtance between Alicuda and Cefalu exceeds five-and-forty miles. It is well known that this optical illuſion takes place with reſpect to any object ſeen at a diſtance, either by land or water. Nothing happens more frequently to the traveller than to find that

two

two rocks, mountains or buildings, which when viewed at a diſtance he had imagined to be extremely near to each other, and almoſt to touch, are in fact ſeparated by an interval of ſeveral miles.

The volcanic materials of Felicuda, as has been already ſeen in the preceding chapter, conſiſt of lavas with a horn-ſtone baſe, ſhoerl, and feltſpar; not to mention pumices, tufas, and glaſſes. The latter three products are likewiſe found in Alicuda, but the greater part of the lavas have the petroſilex for their baſe.

Notwithſtanding theſe two iſlands exhibit indubitable characters of fire, no ſigns of it in a ſtate of activity are at preſent to be ſeen. It may indeed be conjectured that ſome remains ſtill exiſt in the internal parts of Felicuda, from a warm ſpring, emitting the ſmell of ſulphur, which iſſues from the northern ſide of a rock, a little above the level of the ſea.

I ſhall here collect the notices that have been left us by the ancients relative to Felicuda and Alicuda, as they are extremely few and brief. We know that their names were Phenicuſa and Ericuſa (Φοινικουσα and Ερικουσα), which are ſaid to have the following derivation: Ariſtotle, ſpeaking of Phenicuſa, or Felicuda as it is at preſent called, ſays, "it received that name from its abounding in palm-trees"—φοινιξ, in the genitive φοινικος, being the name of that tree in Greek *. Ericuſa, or Alicuda, we are told by the author of the epitome of Stephanus, was ſo named from the *erica* or heath, which there grows plentifully †. Strabo, likewiſe, informs us that theſe two iſlands derive their names from plants ‡. At preſent, however, though heath is not wanting in Alicuda, Felicuda does not afford a ſingle

* Εν μια των Αιολιδ προσαγορευομενων νησων πληθος τι φασι γενεσθαι φοινικων, οθεν και φοινικωδη καλεισθαι.

In Mirandis.

† Ερικυσσα, μια των Αιολιδ νησων, απο φυλης καλυμενη.

‡ Των δε λοιπων Ερικυσσα μεν και Φοινικυσσα απο των φυτων κεκληνται. Lib. VI.

palm-

palm-tree, nor is there one to be found in any of the Eolian iſles.

But neither the above-cited authors, nor any other ancient writers, make the leaſt mention of any conflagrations in theſe two iſlands; probably becauſe, though, in their time, Stromboli, Vulcano, and even Lipari threw out fire, Felicuda and Alicuda, as we have ſeen was the caſe with Didyma and Euonimus, were entirely extinguiſhed.

CHAP. XIX.

OBSERVATIONS WHICH HAVE AN IMMEDIATE RELATION WITH THE VOLCANIZATION OF THE EOLIAN ISLES—ENQUIRIES RELATIVE TO THE ORIGIN OF BASALTES.

Methods and inſtruments proper to raiſe ſtony bodies from the bottom of the ſea ſurrounding the Eolian iſles—The bottom of the channels between Vulcano, Lipari, and Saline, entirely volcanic—The ſame obſervable of the roots of the Eolian iſles below the water—Gravel and volcanic ſand in the channel that divides Panaria from Lipari—The rocks in the middle of the channels between Saline and Felicuda, and between Felicuda and Alicuda, analogous to thoſe of the ſame iſlands, but, probably, primordial—Deciſive proofs deduced from theſe obſervations, that the ſhoerls and cryſtallized feltſpars of the lavas have not been

been taken up by them when in a fluid ſtate, nor formed within them at the time of their congelation—Confirmation of theſe proofs—The Eolian iſles placed in a direct line from eaſt to weſt—A ſimilar direction obſervable in ſome iſlands and volcanic mountains in other countries—Not improbable that all the eight Eolian iſles were formed at the ſame time, and perhaps very ſuddenly, with reſpect, at leaſt, to their firſt rudiments—Explanation of the cauſe why iſlands and burning mountains are ſometimes produced diſpoſed in a right line—Materials of the Eolian iſles, for the moſt part, porphyritic—Analyſis made by the author, proving that the red Egyptian porphyries have not for their baſe the petroſilex, but rather the horn-ſtone—Enquiry whether the vitrifications found in ſuch prodigious quantities at Vulcano and Lipari, are found in ſimilar quantities in any other volcanic countries—Uncertainty of this from the want of accurate mineralogical deſcriptions of the greater part of volcanos—The accounts given of them

uſually

uſually general and wonderful, but little inſtructive—Volcanic glaſs found in Iceland, but by no means in ſufficient quantities to form mountains—No notices of vitrifications in the volcanos of the iſlands of Ferro, nor in thoſe of Norway and Lapland—Little or no glaſs in the volcanized countries of Germany and Hungary—Nor in the extinguiſhed volcanos of France—The quantity of vitrifications at Veſuvius, and ſeveral other parts of the Neapolitan territory, more conſiderable—Scarcely any at Mount Etna, or the volcanic mountains of Padua—A more extenſive tract of pumices found perhaps in no part of Europe than in the iſland of Santorine—This iſland, however, affords no glaſs—Great ſcarcity of vitrifications in the three other quarters of the globe—Concluſion: that Vulcano and Lipari offer a greater abundance of glaſſes than any other volcanized part of the world; but that Santorine exceeds them in the quantity of pumices—Enquiries relative to this ſcarcity of vitrifications in volcanos, whether burning or

extinct

extinct—It seems to proceed less from the quality of the stones acted on by the volcanic fire, than from the inefficacy of that agent to produce vitrification—A successively stronger degree of heat requisite for a stone to pass from the state of lava into pumice, and from that of pumice into perfect glass—Elucidation of the cause why some volcanos produce pumices, but not glasses—The formation of pumices hitherto not attainable in our furnaces—Black the natural colour of pumices, which are rendered white by external causes.

Enquiries relative to basaltes—These originate in the humid way, when the word basalt is understood in the sense in which it was used by the ancients—The columnar stones which, from their prismatic configuration, resemble the basaltes of the ancients, originate according to circumstances in the humid or the dry way.—Proofs of their origin in the dry way in Vulcano and Felicuda—Nature, in the fossil kingdom, produces crystals as well by the dry

way as by the humid—This exemplified in the generation of baſaltes—An abuſe of analogy to conclude from it one common origin of baſaltes—When examined detached, they frequently bear no peculiar character of their origin, which muſt be determined from local circumſtances—Enquiry whether baſaltiform lavas have become ſuch by a ſudden condenſation within the ſea—Proofs which ſhew, firſt, that many baſaltiform lavas have aſſumed this ſymmetrical configuration on coagulation in the waters of the ſea; ſecondly, that in others it has taken place only by congelation in the air; thirdly, that very numerous lavas have proved refractory to this figure, both within the ſea and in the air—The property of aſſuming a priſmatic figure appears, in many lavas, not to depend on their being of a particular ſpecies, nor on their compactneſs and ſolidity, but on extrinſic and adventitious circumſtances—Theſe circumſtances indicated, with an explanation in what manner, according to their preſence or abſence, lavas frequently aſſume a priſmatic

priſmatic form in the air, while others remain irregular within the ſea.

THE form, ſize, and ſtructure of the Eolian iſles, the different materials of which they are compoſed, and the primordial rocks from which theſe are derived; the fires which ſtill burn in ſome, and the phenomena and changes which accompany them; with the compariſon between the preſent conflagrations and thoſe of ancient times, conſtitute the principal objects to be conſidered in writing the volcanic hiſtory of ſuch a country. And though we have already employed nine chapters on theſe ſubjects, we conceive the candid reader will not accuſe us of extreme prolixity; both becauſe we have had to treat of ſeven iſlands, and becauſe our object was to write the Lithology of this ancient and celebrated country. The preſent chapter, we flatter ourſelves, will, in like manner, be acceptable to the enquiring naturaliſt, as it contains various obſervations and reflections

tions which have a direct and immediate relation to the deflagrations of the Eolian iſles.

We have already obſerved and deſcribed theſe iſlands from the ſummit to the baſe, which buries itſelf in the waters of the ſea. But it was impoſſible to examine their internal part in the ſame manner as the external; though the importance of ſuch an examination merited that every effort in our power ſhould be exerted to effect it. It would be equally intereſting and inſtructive to aſcertain the nature of the bottom in thoſe tracts of ſea which ſurround theſe iſlands, and ſeparate them one from the other. I ſhall, therefore, here relate what I obſerved with reſpect to this ſubject, and deſcribe the methods and inſtruments to which I had recourſe to make my obſervations.

Where the depth was not great, I found extremely uſeful the large tongs, mentioned by

by Donati *, furniſhed with ſtrong pincers, fixed to one or more bars, which by means of a rope may be cloſed or opened at pleaſure, and thus take hold of and bring up any ſubſtances fromthe bottom. But where the water was deep, I found it more convenient to employ one of thoſe nets which fiſhermen uſe to envelop, and tear from the rocks, coral and other ſubaqueous bodies. Theſe nets I eaſily procured, as coral is fiſhed up on theſe coaſts; of which fiſhery I ſhall treat further in a ſubſequent part of this work.

Employing, therefore, theſe two inſtruments, the following was the reſult of my obſervations, which were not made on pieces that lay detached on the bottom, but on ſuch as formed a continued whole with it, as was evident from the recent appearance of the fractures where they were broken off.

* Saggio ſopra la Storia naturale del Mare Adriatico —Eſſay on the Natural Hiſtory of the Adriatic Sea.

In

In the channels which divide Vulcano from Lipari, and Lipari from Saline, the bottom is entirely volcanic, and affords products of the ſame ſpecies with the two ſhores. The ſame is obſervable of the foot of the iſlands, which foot in ſome ſituations deſcends perpendicularly; but in others has a conſiderable declivity, and thus enlarges the circuit of the iſland. The pieces of lava which I was here able to detach, did not differ from thoſe of the ſhore, which I have already deſcribed.

But at a greater diſtance between iſland and iſland this was not the caſe. I made my experiments in three different places. The firſt was between Lipari and Panaria; but here, the water being very deep, I did not ſucceed in my attempts to bring up any ſtony body from the bed of the ſea, but only teſtaceous and cruſtaceous animals alive or dead, enveloped in ſand and gravel, and forming a ſpecies of cruſt more or leſs thick. The ſand and gravel, it is to be obſerved, were volcanic.

The

The ſecond place in which I made this experiment was between Saline and Felicuda, and the third between Felicuda and Alicuda, in both inſtances, at the point of greateſt diſtance, as nearly as the eye could meaſure, between the two iſlands. In each of theſe ſituations, beſides drawing up from the bottom portions of the before-mentioned cruſt, I likewiſe obtained ſeveral ſtony fragments, which, from the great force it required to ſeparate them, and the recent appearance of their fractures, evidently had an immediate communication with the ſolid and rocky bottom. The whole number of theſe fragments, great and ſmall, was eleven; of which four were brought up between Felicuda and Alicuda, and ſeven between Saline and Felicuda. The baſe of five * of them was a petroſilex almoſt opake, affording ſparks with ſteel, compact, of a grain a little ſcaly, but fine; the colour

* The author muſt here have committed ſome miſtake, as he, immediately before, ſaid the whole number of pieces was eleven, and now mentions *five* and ſeven. T.

of two of theſe pieces was a lightiſh blue, and that of the three others a grey. The baſe of the ſeven other pieces was a dark-green horn-ſtone moderately hard. None of them differed in their baſe, and ſhoerlaceous and feltſpathoſe cryſtallizations, from ſeveral volcanic lavas of the Eolian iſles.

Theſe eleven pieces, however, excited in me a ſtrong ſuſpicion that the rocks from which they were detached had not been expoſed to the action of fire. The particles of the petroſilex in them were more cloſely united, had greater hardneſs, and a more ſiliceous appearance, than in the ſame ſtone of thoſe iſlands which has been ſubjected to fuſion. In like manner, the lavas of a horn-ſtone baſe uſually have ſomewhat of a fibrous nature, and a thinneſs in their texture which is not ſeen in the ſtone of the ſame kind. Theſe two rocks, therefore, appeared to me to be in their natural ſtate.

I conſider theſe experiments as very inſtructive with regard to the origin and formation

formation of theſe iſlands. We may conclude from them: Firſt, That the part of the iſlands which is buried under the waters of the ſea, has ſuffered the action of the fire in the ſame manner with that which is expoſed to the eye of the obſerver. Secondly, That Vulcano, Lipari, and Saline form one continued group of volcanized ſubſtances, which, at firſt, might probably have one common central conflagration, that, dividing into three branches, and affording a paſſage to three diſtinct mouths, gave birth to three iſlands, which conflagration, by ſubaltern and ſucceſſive ramifications, and ejections of new matters, afterwards increaſed in extent. No ſenſible remains, indeed, of ſuch a fire are at preſent diſcoverable in the internal parts of Saline, nor are any obſervable in Lipari, its whole efficacy appearing to be confined to Vulcano. Thirdly, That Alicuda, Felicuda, and Saline do not appear to have any volcanic communication with each other, at leaſt in the parts that form the bed of the ſea, which ſeparates theſe three iſlands from each other;

ſince thoſe parts, as far as the eye can perceive, ſhew no ſigns of the action of fire. Fourthly, That theſe three iſlands, and perhaps likewiſe Stromboli, are ſituated in the vicinity of analogous but primitive rocks. The perfect reſemblance of the ſhoerls and feltſpars in theſe rocks, both in thoſe that have ſuffered change from the fire and thoſe that have not, is a demonſtration that theſe cryſtallizations have not been taken up by the lavas when they flowed in currents, nor formed in them at the time of their congelation.

From the very beginning of this work, I have adduced facts of the ſame nature, which I have the ſatisfaction to confirm by the preſent; and which become of the greater importance, as I have lately read that a naturaliſt of eminence inclines to believe that the ſhoerls of lavas are formed when the latter condenſe and become cold, becauſe then the homogeneous molecules ſeparate from the heterogeneous, and unite by affinity in ſmall cryſtallized maſſes.

This

This ingenious theory is not only contradicted by the obſervation made above, but appears to me not to accord with the uſual operations of Nature. Were it well founded, I can perceive no reaſon why the ſhoerls in lavas ſhould not re-appear after they have been fuſed within them in the furnace, and, being removed into a cold place, have acquired their former hardneſs. But though I made experiments with fire on ſome thouſands of pieces of lava, not one of them re-produced its ſhoerls, though many were continued a long time in a ſtate of fuſion, and afterwards ſuffered quietly and ſlowly to cool and conſolidate; which two circumſtances are known to favour the formation of cryſtallizations. Shoerls were, indeed, ſometimes found in the lavas, after fuſion, when cooled and hardened; but theſe had proved refractory to the fire; as appeared on expoſing them again to the furnace detached from the lava.

The eleven pieces of primordial rock

broken from the bottom, exhibited in the furnace the ſame changes with their congenerous lavas expoſed to the ſame fire : the feltſpars, however, remained refractory.

The Lipari iſlands extend in a right line from eaſt to weſt the diſtance of about fifty miles, except that Vulcano makes a ſmall angle. Stromboli is the firſt to the eaſt, and Alicuda the laſt to the weſt. This is not the only inſtance of volcanos having produced iſlands, or rather mountains, arranged in a rectilinear direction. We find an example of this in the Moluccas, which are the produce of ſubterranean fires, and placed one beyond the other in a right line. When, in 1707, a new iſland was thrown up by a ſubmarine volcano, in the Archipelago, near Santorine, other ſmall iſlands aroſe from the ſea near it, to the number of ſeventeen, in a right line, forming, as it were, a long chain of black and dark rocks, which viſibly increaſed in dimenſions and height, and, approaching each other, at length united,

united, and, joining that which firſt aroſe from the water, formed one ſingle iſland*.

Another memorable inſtance of this direction of volcanic mountains (for iſlands are in fact only mountains buried in part under water) is the production of ſeven leſſer mountains by the eruption of Veſuvius in 1760; the account of the formation of which, as it may throw ſome light on that of the Eolian iſles, I ſhall here give, from the accurate relation of Profeſſor Bottis, an ocular witneſs.

After repeated concuſſions of the earth, which were felt fifteen miles round Veſuvius, the ſides of the fiery mountain opened in the territory of the Torre del Greco, and fifteen volcanos appeared, eight of which were ſoon after covered by a torrent of lava, which ruſhed from one of them; the other ſeven remaining entire, and inceſſantly ejecting from their mouths vaſt quantities of ig-

* Valliſneri Oper. fol. t. ii.

nited ſubſtances, which falling almoſt perpendicularly around the volcanos, produced, in the ſhort ſpace of ten days, ſeven ſmall mountains, of various heights, diſpoſed in a right line. During theſe ejections, the noiſe which accompanied them ſometimes reſembled that of violent thunder, and at others the diſcharge of a number of cannons. Several of the burning ſtones, even the largeſt, were thrown to the height of nine hundred and ſixty feet, and ſome fell at a conſiderable diſtance from the mouth whence they were thrown. Theſe eructations ſhook all the neighbouring country, and the roarings of the mountain were dreadful to the inhabitants. After the tenth day, the eruptions ceaſed, and the newly-formed mountains, gradually cooling, permitted a nearer approach; when ſome were found to have at their ſummit a cavity reſembling an inverted funnel, and others a ſimple hollow, of greater or leſs depth.

The production of the Eolian iſles being anterior to the records of hiſtory, we know not

not whether this took place at one time, or in different periods. The relation, however, juſt cited, of the origin of the ſeven Veſuvian mountains clearly proves the poſſibility of their being produced at the ſame time. It alſo proves, that the whole eight might be formed in no long ſpace of time, with reſpect at leaſt to their firſt rudiments, it having been ſeen that they have received ſucceſſive additions.

We alſo evidently perceive, that the inflammable ſubſtances generative of the Moluccas in Aſia, of the chain of iſlands at Santorine, of the Veſuvian mountains above deſcribed, and of the Eolian iſles, have formed a direct ſubterranean zone incomparably longer than broad. This phenomenon may be explained by recurring to the clefts and fiſſures perpendicular to the horizon, exiſting in many places within the earth, as well in ſoft ſubſtances as in the more durable and ſolid; within which clefts ſhould ſubſtances proper for the production

of

of volcanos be found in abundance, and become inflamed, in ſeparate heaps, burning mountains would ariſe, in a direct line, and more or leſs large, according to the quantity of the ejected matters.

From the particular deſcriptions of the iſlands of Lipari, we have ſeen that the combuſtible ſubſtances which have produced them have ſometimes been contained within granite, as at Panaria and Baſiluzzo, but for the moſt part within rocks which have for their baſe the petroſilex, the horn-ſtone, and the feltſpar. It likewiſe appears, from the obſervations made at Stromboli, that, even there, theſe burning ſubſtances have their ſeat in the horn-ſtone rock, though, from the ſize of the iſland they have produced, they muſt undoubtedly be buried at an immenſe depth. If we would ſimplify the facts relative to the materials of all theſe iſlands, we ſhall find that they are for the greater part porphyritic; as are likewiſe ſome of thoſe ſubmarine tracts, apparently

not

not touched by the fire, and placed among them; as has been ſhewn above *.

When I compared the effects of the furnace on volcanized porphyritic rocks with thoſe it produces on the natural, I mentioned ſome red Egyptian porphyries, the baſe of which I believed to be horn-ſtone, rather than petroſilex, relying on the analyſes of Bayen, as related by Delametherie, of an Egyptian porphyry of the ſame colour, and ſimilar to thoſe on which I made my experiments †. But not having then been able to analyſe them, from want of time, I determined to do it afterwards, and give an account of the reſult, in another part of this work, when I ſhould again have occaſion to ſpeak of this ſpecies of volcanic rock. I ſhall here give this analyſis, which affords a confirmation that the baſe of theſe porphyries is not petroſilex, as they contain magneſia, which is not found in that ſtone.

* See the Note at page 82, Chap. XI, in which I have ſpoken of the eſſential characters of porphyry.

† See Chap. XI.

From this circumſtance, and the nature of their conſtituent principles, their baſe ought rather to be called a horn-ſtone, of the nature of which it at leaſt participates. This analytical obſervation is likewiſe here very opportune, as it is an additional proof that I have properly called porphyritic the lavas with a horn-ſtone baſe, and containing felt-ſpars, which are ſo numerous in theſe iſlands.

The red Egyptian porphyries which I analyſed are of two ſpecies: the firſt has been deſcribed at page 118 of Vol. II.: the ſecond differs only in its colour being of a leſs lively red, and in the abundance of its feltſpars. It is evident, that to render this experiment accurate, the ſubſtance of theſe two ſtones ſhould be firſt freed from the ſhoerls and feltſpars which they contain.

Firſt Species.

Silex, ſomewhat reddiſh, -	80
Alumine - - -	7
Lime - - -	3

Magneſia

Magneſia - - -	2
Iron - - -	6

Second Species.

Silex - - -	81
Alumine - - -	$7\frac{1}{2}$
Lime - - -	4
Magneſia - - -	2
Iron - - -	$4\frac{1}{2}$

Beſides the porphyritic lavas with which the Eolian iſles abound, we have ſeen that they contain great quantities of tufas; and that Stromboli is diſtinguiſhed from the other iſlands not only by its volcano, but by the beautiful ſpecular iron it affords; and Lipari by its chryſolites and zeolites, but ſtill more by the prodigious quantities of pumices and glaſſes which it contains. I cannot, indeed, reflect on thoſe enormous maſſes of vitrifications, without renewed wonder; which has been ſtill more increaſed by the diſcovery, by means of the forceps and coral net, that theſe vitrifications are continued from Lipari, till they join thoſe of Vulcano, which

on

on the north and north-eaſt ſide abounds in pumices, enamels, and glaſſes. The vitreous ſubſtances, therefore, of this iſland, and thoſe of Lipari, which, as has been ſaid, occupy about two-thirds of the latter, compoſe an accumulation of glaſs, not leſs than fifteen miles in circuit. It is impoſſible to attend to this ſtupendous phenomenon without feeling our curioſity excited to know whether it be peculiar to theſe iſlands, or found likewiſe in other volcanized countries. But ſatisfactorily to anſwer ſuch a queſtion, it would be requiſite that we ſhould be acquainted with the volcanic mineralogy of all the volcanos in the world; not only thoſe at preſent burning, but thoſe extinguiſhed, which are infinitely more numerous; in the ſame manner as we are with that of Vivarais and Velay, the iſlands of Ponza, Veſuvius, Etna, the Eolian iſles, and the mountains of Old-Briſach, by the labours of Faujas, Gioeni, Dolomieu, Dietrich, and myſelf. Of ſuch a mineralogy, however, we are entirely deſtitute. The greater part of thoſe who, either by chance, or from curioſity,

have

have viewed burning volcanos, have only deſcribed in their relations the moſt common and general phenomena, leſs adapted to increaſe the knowledge than to amuſe the imagination of their readers, and excite their wonder——Shocks and undulations of the earth—the ſea in commotion, and raging without a tempeſt; here retiring and leaving its ſhores dry, and there inundating vaſt tracts of land—ſubterranean thunders, and roarings in the air above—the ſun diſappearing in thick darkneſs at noon—whirlwinds of ſmoke, aſhes, and flame, burſting from the yawning gulf—burning ſtones hurled towards heaven, and falling in a fiery hail—torrents and rivers of liquid lava, ſulphur, and bitumen, pouring down on the valleys below, and carrying terror, deſolation, and death—iſlands, now ſuddenly produced by ſubmarine eructations, and now torn from their foundations, and ſwallowed up by earthquakes——theſe compoſe the uſual deſcriptions of volcanos, which, though they may not be uſeleſs when the facts are faithfully ſtated, and not magnified by the imagination

gination of the narrator; yet they commonly want one eſſential requiſite; that is, lithological deſcriptions of the bodies ejected by theſe burning mountains. As glaſs and pumices, however, are known even to thoſe who are unacquainted with this part of natural ſcience, we may, with certainty, or, at leaſt, with the ſtrongeſt probability, conclude, that they are produced by the volcanos in the deſcriptions of which we find them expreſsly mentioned as making a part of the ejected matters, and that they are not produced when not mentioned. Thus in Iceland, the greater part of which iſland is only an accumulation of volcanos either extinct or active, it is certain, from the accounts of travellers, that numerous glaſſes are found, to which the name of Icelandic agate has improperly been given, only becauſe they have the luſtre and beauty of that ſtone. The preſent eruptions of this iſland, likewiſe, not unfrequently contain pumices; but no perſon has ever aſſerted that there are entire mountains of theſe ſtones, or of glaſſes.

The iſlands of Ferro are conſidered as volcanic, and produce the famous zeolites, mixed, as it is ſaid, with lava; but as yet we know nothing more of them. The minute account of each of theſe ſeventeen iſlands, publiſhed by Jacobſon Debes, in which no mention is made of the vitrifications, authorizes us to conclude they do not exiſt there.

Norway and Lapland have their volcanos, which from time to time burſt forth in fearful eruptions, according to the accounts of Pennant and others, who, however, give us no further information.

Leaving theſe cold regions, and paſſing to Germany and Hungary, we find ſome tracts of theſe countries that have likewiſe been ſubjected to ſubterranean conflagrations, which, however, have produced no vitrifications, or ſcarcely any. "I have ſought in vain the black agate of Iceland, and the true pumice," ſays the above-cited Baron Dietrich, in his long and circumſtan-

tial Memoir relative to the volcanos near Old-Brifach.

Proceeding to a milder climate, and approaching nearer to our own country, we find that the extinct volcanos of France afford no pumices or glaſſes; which aſſertion I can make on the authority of M. Faujas, who has written ſo well concerning them, than which one more unqueſtionable cannot be adduced.

It is not the ſame with Italy; the country in which fire has principally extended its empire. The Neapolitan territory peculiarly abounds in pumices, enamels, and glaſſes, as appears in the iſlands of Ponza, at Herculaneum, Pompeii, Miſeno, Monte Nuovo, the Rock of Burnt Stones, Procida, Iſchia, and the valley of Metelona *. Even in our times Veſuvius has ejected ſimilar bodies; but, with reſpect to Etna, its fires rarely produce the ſlighteſt vitrification.

* See Chaps. IV, V, VI.

The

The only place in Europe, which, in the abundance of its pumices, can equal, or perhaps ſurpaſs Lipari, is the iſland of Santorine. On this ſubject we may conſult Thevenot and Tournefort, two intelligent travellers, who at different periods examined this iſland, which has not hitherto, to my knowledge, been conſidered by volcaniſts in this point of view.

The former, who viſited Santorine in 1655, obſerves, that " many of the inhabitants live in caves, made under the earth, which is extremely light, and eaſily dug into, as it conſiſts entirely of pumices." He afterwards relates a fact, which has a particular relation to our preſent ſubject, ſince it teaches us in what manner theſe light ſtones may be thrown up, immediately by the ſea, in volcanic eruptions. His account is as follows :

" About eighteen years ago, on a Sunday " night, a violent noiſe began to be heard " in the port of Santorine, which was like-

" wife heard even to Chios, diſtant more
" than two hundred miles, and was thought
" to be occaſioned by the Venetian fleet
" having engaged the Turks; in conſe-
" quence of which great numbers of people
" got upon the higheſt places early in the
" morning, to be ſpectators of the battle;
" and I remember the Reverend Father
" Bernardo, a venerable man, perfectly de-
" ſerving credit, told me he was one among
" the number of thoſe who were ſo de-
" ceived, imagining they heard a violent
" cannonade. They could however ſee no-
" thing. In fact, this noiſe was cauſed by
" a fire kindled in the earth, under the har-
" bour, the effect of which was, that from
" the morning to the evening a vaſt quan-
" tity of pumices roſe from the bottom of
" the ſea, with ſuch violence and noiſe as to
" reſemble repeated diſcharges of cannon,
" and ſo infected the air that ſeveral perſons
" died at Santorine, and many loſt their
" ſight, which they did not recover till
" ſome days after. This infection extended
" as far as the noiſe which had preceded it had
" been

" been heard ; ſince not only in this iſland,
" but at Chios and Smyrna, all the ſilver
" became red, whether kept in coffers or
" in the pocket ; and the religious who re-
" ſided there told me that all their chalices
" became red. After ſome days the infec-
" tion ceaſed, and the ſilver returned to its
" former colour.

" The pumices which were thrown up
" covered the Archipelago in ſuch a man-
" ner, that, for ſome time, when certain
" winds prevailed, the harbours were ſo
" blocked with them, that not even the
" ſmalleſt veſſels could get out till a way
" was made for them by removing the
" pumices with long poles, and they are
" ſtill ſeen ſcattered over the whole Medi-
" terranean, though in a ſmall quantity *."

Tournefort, after having remarked from Herodotus that Santorine was once called Καλλιστη or " the moſt beautiful iſland," adds, that " its ancient inhabitants would

* Voyages de M. de Thevenot, Prem. Part.

" not at preſent know it, ſince it is covered " with pumices, or, more properly, is a " mine of thoſe ſtones, which may be cut " into great ſquare blocks, as other ſtones " are cut in the quarries *."

According to this traveller and to Thevenot, Santorine is thirty-ſix miles in circuit ; whence it appears what a prodigious accumulation of pumices there muſt be in this iſland and the adjacent ſea. It merits notice, however, that neither theſe two travellers, nor others who have written of Santorine, make the leaſt mention of glaſſes of any kind ; we may therefore venture to affirm that the ſubterraneous fires have, there, never produced them.

If from Europe we paſs to the three other quarters of the globe, we ſhall find in each a great number of volcanos, which it would be ſuperfluous to enumerate particularly, ſuch an enumeration having al-

* Voyage du Levant.

ready

ready been made by Faujas, Buffon and others. I ſhall only mention thoſe which afford products that have relation to our preſent ſubject.

We read that the iſland of Ternate, in Aſia, throws out a conſiderable quantity of pumices, as does, likewiſe, one of the numerous volcanos of Kamſchatka.

As to thoſe of Africa, we have but very imperfect accounts of them, with the ſingle exception of the peak of Teneriffe, one of the loftieſt of volcanos; which, with reſpect to its ſituation, height, form, and crater, and the hot fumes which iſſue from it, has been accurately deſcribed by the Chevalier Borda. But it were to be wiſhed that we had a more complete deſcription of the materials of which it is compoſed; as the French traveller only tells us that they are "ſand, black and red calcined ſtones, pumices, and flints of different kinds *."

* Voyage en diverſes Parties de l'Europe.

It admits of no doubt that the higheſt mountains of America, as Chimboraço, Coltopaxi, Sangai, Pichencha, &c. form a chain of burning volcanos, the largeſt exiſting in nature. We are indebted for the accounts we have of them to M. Bouguer; but theſe are ſuch as only tend ſtrongly to excite our curioſity without gratifying it. With reſpect to what relates to our preſent enquiry, we only learn from this writer, that "ſome mountains in the vicinity of Quito "are compoſed entirely, to a great depth, "of ſcoriæ, pumices, and fragments of "burnt ſtones of every ſize *." As to volcanic glaſſes, he does not make the ſlighteſt mention of them; though it is well known that the famous gallinaceous ſtone, which is univerſally acknowledged to be a moſt beautiful American volcanic glaſs, of a black colour, is found in Peru, and that, according to M. Godin, there is a mine of it, ſeveral days journey from Quito.

* Acad. Royale des Sciences, 1744.

If

If we now conſider thoſe parts of theſe imperfect accounts which relate to glaſſes and pumices, we ſhall find, with reſpect to the former, that the much greater part of volcanos produce none, and that thoſe which do produce them, as in the Neapolitan territory, Iceland, and Peru, are by no means to be compared in this reſpect with Lipari and Vulcano. The ſame may be aſſerted of Alicuda and Felicuda, the glaſſes of which, though abundant in many parts of thoſe iſlands, are only found in flakes and fragments. Theſe obſervations might likewiſe be applied to the pumices, did not the immenſe quantity of them in the iſland of Santorine equal, if not exceed, that of the two Eolian iſlands above mentioned.

If we conſider the volcanos known to us under one general point of view, we ſhall find that, though they have changed into lavas an infinity of rocks, by which they have produced mountains and iſlands very conſiderable both in number and dimenſions, it is very rarely that they vitrify the

ſubſtances expoſed to their fires. Reflecting on the immenſe quantities of vitrifications at Vulcano and Lipari, which are almoſt all derived from feltſpars and petroſilex, the idea ſuggeſted itſelf to my mind, whether ſo great an abundance in theſe two places, and ſo great a ſcarcity in others, might not be attributed to theſe ſtones being here extremely abundant, and very rare elſewhere. But this ſuppoſition does not accord with fact; as we have ſeen in many other volcanic tracts, which I have deſcribed, and ſhall deſcribe when I come to ſpeak of the Euganean mountains, that both theſe ſtones may be changed into lava without that lava exhibiting the ſlighteſt appearance of glaſs. On the other hand we have ſhown, that, beſides feltſpar and petroſilex, many pumices have for their baſe the hornſtone and aſbeſtus, and many granite, as M. Dolomieu has obſerved. I am, therefore, of opinion that the cauſe which has produced them ſhould rather be ſought in the volcanic fire, which rarely has ſufficient activity to vitrify the ſtones and rocks on which

which it exerts its power; though I grant that the petroſilex and feltſpar are more adapted to this vitrification than other ſtones. To produce a lava, a certain degree of heat is neceſſary; and a ſtill greater to convert it into pumice. The lavas, at leaſt thoſe of the compact ſpecies, uſually preſerve the grain, hardneſs, and ſometimes the weight and colour of the primordial rock; but the greater part of theſe external qualities diſappear in the pumice, from the ſtronger action of the fire. This muſt operate ſtill more in glaſs, in which the homogeneity and fineneſs of the paſte efface every trace of its primitive texture.

Theſe gradual tranſitions of lava into pumice, and pumice into glaſs, I have ſeveral times obſerved, and indeed have already deſcribed, in the ſame volcanic piece. It has alſo been obſerved, that a lava frequently paſſes immediately into perfect glaſs, which muſt be cauſed by a ſudden heat, greater than that required to change it into pumice. This theory ſatisfactorily explains why

why ſome volcanos produce pumices, but never glaſs; as may be remarked of Santorine. Their fires are only ſufficiently powerful to generate pumices, but not to produce glaſs; an obſervation applicable to the prodigious eruption from the ſea deſcribed by Thevenot. On the contrary, at Rotaro in Iſchia, at Veſuvius, and other parts of the Phlegræan Fields, as alſo at Vulcano, Lipari, Felicuda, and Alicuda, glaſſes are found mixed with lavas; which ſhews that the fire has acted unequally in thoſe places. It is to be remarked, at the ſame time, that the heat requiſite for vitrification is not of the moſt violent kind, as I have ſhewn in Chap. XVI.

We muſt however obſerve, that as the production of compact lavas is a ſecret which Nature has hitherto reſerved to herſelf; ſince we are unable to imitate them with our common fires; ſo alſo are we ignorant of the preciſe cauſes of the formation of pumices. Among ſome thouſands of fuſions which I have made in the furnace,

nace, both of lavas and primordial rocks and ſtones, thoſe likewiſe from which pumices are moſt frequently produced, as petroſilices and feltſpars, I never obtained a product which could be ſaid to poſſeſs all the characteriſtics of pumice. It has always been either a glaſs, an enamel, or ſcoriæ; nor do I remember to have read or heard, that among the innumerable experiments which chemiſts have made upon earths with fire, the reſult ever was a true pumice: and though in lime-furnaces we may frequently obſerve a change of certain ſtones into glaſs; yet they never produce lavas ſimilar to the volcanic; and equally incapable are they to form pumices. It cannot be alleged that the fire of our furnaces is too ſtrong to induce that ſlight degree of vitrification which characterizes pumices; ſince, when I have uſed a more moderate fire, the ſubſtances on which I made my experiments have either not melted, or been more or leſs vitrified.

I ſhall conclude theſe obſervations on the pumices

pumices of Lipari with a remark relative to their colour. Except a few that are dark, they are all white as ſnow. Hence the mountain of Lipari, which forms the great magazine of theſe ſtones, is called *Campo Bianco* (the White Field): but certainly there muſt have been a time when it ſhould have been denominated *Campo Nero* (the Black Field); at leaſt it is certain that pumices when newly ejected from volcanos are of a black colour. This remark, which has been omitted by almoſt all who have made obſervations on this ſubject, who content themſelves with ſaying that this or the other volcano throws out pumices, has been expreſsly made by Don Gaetano de Bottis in his "Hiſtory of the Conflagrations of Veſuvius *." He tells us, the pumices ejected at various periods by this volcano are black. He likewiſe remarks, that on comparing them with thoſe which overwhelmed Pompeii, he found them perfectly ſimilar in their ſtructure.

* Iſtoria di varj Incendj del Veſuvio.

Their

Their whiteneſs was ſubſequently acquired, and probably was cauſed by the impreſſions of the atmoſphere.

Before I conclude theſe obſervations on the Eolian iſles, I think it neceſſary to ſay a few words on a ſubject which has a relation to the productions of Vulcano and Alicuda, and on which the opinions of modern naturaliſts are divided ; I mean the baſaltiform lavas which are found within the crater of the former iſland, and along the ſhores of the latter *, and which by their conformation cannot but remind the reader of the enquiries and diſputes which have taken place within theſe few years relative to the origin of baſaltes. To repeat all that has been written on the ſubject would fill a volume ; but I am far from purpoſing to tire either my own or the reader's patience in any ſuch manner. It, beſides, appears to me that this long agitated queſtion may, at preſent, be determined

* See Chaps. XIII and XVII.

without

without any very prolix argumentation. Literary diſputes and differences of opinion frequently ariſe from want of previouſly fixing the ſtate of the controverſy; that is, from not defining in preciſe and clear terms the thing in queſtion. Before we enquire what is the origin of baſaltes, that is to ſay, whether they are the reſult of the action of fire or water, it will be proper to decide what we mean by the term; or rather what the ancients underſtood by this word, which is the name they gave to a certain kind of ſtones. It is now generally known, becauſe it has been repeated by a hundred writers, though perhaps by the greater part without due conſideration, that the word baſaltes is uſed by Pliny and Strabo to denominate an opake and ſolid ſtone, of the hardneſs, and nearly of the colour, of iron, commonly configurated in priſms, and originally brought from Ethiopia; of which ſtone the Egyptians made ſtatues, ſarcophagi, mortars, and various utenſils. This premiſed, it remains to enquire whether this ſtone was of volcanic origin or not,

by

by repairing to the places where it was found, and attentively examining the country to diſcover whether it bears the characteriſtics of volcanization. This labour, however, has not, to my knowledge, been hitherto undertaken by any one; but M. Dolomieu, to whom Lithology and the Hiſtory of Volcanos are ſo much indebted, has diſcovered, during his ſtay at Rome, an equivalent, in ſome meaſure, with reſpect to the ſolution of this queſtion. Among the many noble monuments in that ſuperb capital which are inſtructive not only to the admirers of the arts, but to the contemplators of nature, are a great number of ſtatues, ſarcophagi, and mortars brought from Egypt, which have all the characters attributed to baſaltes, and likewiſe preſerve the name. Theſe he has ſtudied with the greateſt attention, and declares that the ſtone of which they are formed manifeſts no ſign of the action of fire. Among other Egyptian monuments, he obſerved ſome of a green baſaltes, which change colour, and aſſume a brown tinge, ſimilar to

that of bronze, on being expoſed to the ſlighteſt heat. All thoſe that have been burned have acquired this colour; which proves, as he very judiciouſly obſerves, that the green baſaltes have never ſuffered the action of fire *.

The Egyptian ſtones, therefore, to which the ancients gave the appellation of baſaltes, have been produced by Nature in the humid way. Theſe obſervations perfectly agree with thoſe of Bergmann on the trapps produced in the ſame way; and which have, both externally and internally, the ſame characteriſtics with the baſaltes †.

Werner, taking the term baſaltes in a wider ſenſe, and underſtanding by it all thoſe columnar ſtones which, by their priſmatic configuration, reſemble the Egyptian baſaltes, ſuppoſes both to have the ſame origin, and adduces, as a proof of that origin, the baſaltes of the hill of Scheibenberg,

* Rozier, tom. xxxvii. an. 1790.

† De Productis Vulcanicis.

which

which are the effect of a precipitation by means of water; and concludes that "all baſaltes are formed in the humid way *."

Though I am willing to beſtow the praiſe due to his diſcovery, I cannot admit his concluſion; for though many baſaltes, taking that term in the ſenſe of this author and other naturaliſts, may derive their origin from water, many others are certainly the product of fire.

I ſhall not repeat what various volcaniſts have written on this ſubject, but merely refer the reader to what I have already ſaid relative to the baſaltine lavas of Vulcano and Felicuda. With reſpect to the former iſland, I have remarked, in Chap. XIII, that I found within its crater a range of articulated priſms, with unequal ſides and angles, which, in part, compoſed one whole with a maſs of lava; and, in part, were detached from it. I have alſo there

* Rozier, tom. xxxviii. an. 1791.

deſcribed the qualities and nature of theſe priſms. In Chap. XVII I have particularly deſcribed the litoral lavas of Felicuda, which, near the water, are priſmatic.

It is therefore evident, that, in theſe two ſituations, the origin of the baſaltes there found cannot be what it has been aſſumed, generally, by Werner and other Germans, but that it is truly volcanic. It conſequently appears that Nature obtains the ſame effect by two different ways. In the foſſil kingdom, one of her grand operations is cryſtallization ; which, though it be moſt frequently effected in the humid way, is ſometimes produced in the dry ; as we ſee, among other inſtances, in iron, which Nature cryſtallizes within the earth, both by the means of water and of fire, in which latter way the beautiful ſpecular iron of Stromboli is produced *. Nor are there wanting other inſtances, of the cryſtallization of the ſame metal by the action of fire.

* See Chap. XI.

And

And did other metals exiſt in the entrails of volcanos, and the neceſſary circumſtances concur to their cryſtallization, it is indubitable that this may be effected by fire as well as by water. Thus we ſee that, by taking certain precautions, metallic ſubſtances aſſume a regular and ſymmetrical diſpoſition within the crucible. The ſame is true of baſaltes, the priſmatic configuration of which, though not ſtrictly a cryſtallization, has the moſt exact reſemblance to it. Obſervation, likewiſe, teaches us that the ſame combination of earths, according to different circumſtances, forms priſmatic baſaltes, ſometimes in the humid, and ſometimes in the dry way. The ſtone called trapp, found in the mountains of Sweden, is configurated in priſms, though thoſe mountains are of aqueous origin; and the horn-ſtone, which is ſo analogous to the trapp, has the ſame configuration at Felicuda, notwithſtanding it is a true lava. In the ſame iſland, likewiſe, other baſaltiform lavas have for their baſe ſhoerl in maſs, and thoſe of the crater of Vulcano,

the petroſilex ; which two ſtones, according to the obſervations of M. Dolomieu, form ſome of the Egyptian baſaltes, which are a work of the waters. Theſe two agents, fire and water, are not, in fact, ſo different in their action as we might at firſt be inclined to imagine. The priſmatic figure in the humid way ariſes in the ſoft earth by the evaporation of the water ; in conſequence of which the parts dry, contract their volume, and ſplit into polygonal pieces. The ſame phenomenon may be remarked in margaceous earths, imbued with water, and expoſed to the ventilation of the air ; and I have frequently ſeen the mud of rivers, when dried in the ſun, in ſummer, to make pottery-ware, divide, when it became dry, into ſmall polyedrous tablets. Similar configurations are produced in different lavas by the congelation and contraction that take place by the privation of the fire which held them in a ſtate of fluidity.

It appears to me, therefore, that the diſpute

pute relative to the origin of baſaltes is at an end ; nor would there be any difference of opinion if, inſtead of generalizing ideas and fabricating ſyſtems, naturaliſts would make an impartial uſe of their own obſervations and thoſe of others. Some volcaniſts, perceiving that the generation of various baſaltes is evidently igneous, have immediately inferred that all muſt have the ſame origin. In conſequence of this principle, they have drawn lines or zones, in different parts of the globe, indicative of extinct volcanos, which they have inferred from finding baſaltes there; and thus pourtrayed a picture of prodigious dimenſions, repreſenting the ruins cauſed in the world by ſubterranean conflagrations. Other naturaliſts, on the contrary, being convinced that certain baſaltes are the produce of water, have aſſigned to all the ſame origin. From the facts now adduced, it is, however, ſufficiently evident that both theſe hypotheſes are erroneous. The baſaltes, taking the term generally, when examined detached, do not bear excluſively any deciſive

marks of their origin. Local circumſtances alone can determine to which of the two principles it is to be aſcribed; to diſcover which we muſt attentively examine whether the places where theſe figured ſtones are found exhibit any indubitable ſigns of volcanization. Yet even theſe are frequently not ſufficient, as there are many hills and mountains which owe their origin to both the great agents of nature, fire and water; in which caſe it will be neceſſary to redouble our attention, and fix it on the ſubſtances originating from each; to determine, by the relations theſe have to the baſaltes, from which of the two the latter derive their formation. By diligently employing theſe means, we ſhall be certain, without fear of error, to elucidate and advance the enquiries relative to baſaltes, and be enabled accurately to determine which of them are to be aſcribed to the action of water, and which to that of fire.

But here a ſecond queſtion occurs, not leſs intereſting than the firſt, relative to the cauſe

cauſe why certain lavas, differing from innumerable others, become baſaltiform; ſince, if this configuration depended on congelation, it muſt be found in all lavas when they had ceaſed to flow. The firſt writer, to my knowledge, who has adverted to this is M. de Luc, who, in the ſecond volume of his Travels, is of opinion that they have taken this regular figure in the ſea, by the ſudden condenſation which took place on their flowing into it in a liquid ſtate; other ſecondary circumſtances, however, concurring, ſuch as a greater homogeneity, and a certain attraction of their parts.

Of the ſame opinion is M. Dolomieu; though he does not deny that even porous lavas may ſometimes, likewiſe, take the form of priſms. The former of theſe opinions is little leſs than hypothetic, while the latter is ſupported by facts too important to be curſorily ſtated. M. Dolomieu obſerves that all the currents of the lavas of Etna, the periods of which are preſerved in hiſtory,

hiſtory, have conſtantly experienced two effects in their congelation. Thoſe which have cooled in the air, have divided, in conſequence of the contraction they have ſuffered by the loſs of their caloric (heat , into irregular maſſes ; while all the others, which have precipitated into the ſea, have, on their ſudden congelation, contracted in a regular form, and divided into priſmatic columns, which form they have only taken in the parts in contact with the water of the ſea. Of this he met with evident proofs along the ſhore which extends from Catania to Caſtello di Jaci ; and the famous lava of 1669, though unapt to the priſmatic form, from being ſpungy and little in quantity, yet in ſome parts exhibits a kind of rude imperfect priſms.

Among the objects to which I was attentive in my volcanic travels through the two Sicilies, the priſmatic lavas were certainly not the laſt. While making the circuit of the Eolian iſlands, of Etna and of Iſchia, I conſtantly obſerved carefully the conformation of the ſtony currents which fall

fall into the ſea. I have remarked, when treating of Iſchia, that this configuration is frequently priſmatic, and that the priſms are conſtantly formed in thoſe parts of the currents which immerge into the water, and reach to a few feet above the level. This obſervation of mine certainly accords admirably with thoſe of M. Dolomieu; the ſituation of theſe priſms clearly ſhowing that they were formed at the time of the immerſion of the lava into the ſea, which, when it flowed, roſe to where they begin to appear. But, though I agree with him in this, I cannot in the remainder of my obſervations. Alicuda, as well as Felicuda, preſents us with numerous currents and rocks that deſcend into the ſea; and they are likewiſe found at Saline, Lipari, Stromboli, Panaria, Baſiluzzo, and Vulcano; but theſe rocks and currents, which together extend over a ſpace of more than ſixty miles, do not afford the ſlighteſt indication of priſms.

As I went by ſea from Meſſina to Catania,

nia, and returned to Meſſina from Catania, I had an opportunity twice to examine, at my leiſure, that tract of ſhore, which, for the ſpace of nearly three-and-twenty miles, is volcanic. One third of it, beginning at Catania, and proceeding to Caſtello di Jaci, conſiſts of priſms more or leſs characterized, and ſuch as they have been deſcribed by M. Dolomieu; but the other two thirds, though equally compoſed of lavas with the former, and for the moſt part falling perpendicularly into the ſea, have no ſuch figure; and only preſent, here and there, irregular fiſſures and angular pieces, ſuch as are, generally, obſervable in all lavas, which ſeparate more or leſs on their congelation.

In my circuit by ſea round the ſhores of Iſchia, I was particularly attentive, as I was every where elſe, to the conformation of the lavas; and here there ſeemed a great probability of finding them priſmatic, from the abundance of them which in different directions and angles fall into the

the ſea: but I have already obſerved, when treating of the iſland, and I now repeat it, that I did not find one with a regular form.

At Naples, the priſmatic lavas of the currents of Veſuvius, under the Park of Portici, have been much ſpoken of. When I made my obſervations on this burning mountain, I had not time to viſit theſe lavas. It is with great pleaſure, therefore, that I learn they have been examined by a perſon ſo well experienced in matters of this nature as the Chevalier Gioeni undoubtedly is. But the celebrated priſms diſapppeared in the preſence of ſo accurate an obſerver. The following is the account he gives; which is of conſiderable importance to our preſent ſubject:—"I wiſhed "to examine the baſaltes which were "pointed out to me as to be found on the "ſea-ſhore, under the Royal Park of Por-"tici; but they proved to be only a com-"pact lava, with perpendicular and ex-"tremely irregular fiſſures, forming qua-"drangular,

" drangular, and ſometimes trapezoidal pi-
" laſters, which have been employed in
" buildings. Similar fiſſures are likewiſe
" obſerved in tufas, and earths of different
" kinds, and can never miſlead any perſon
" accuſtomed to them, and acquainted with
" their true cauſes."

By this faithful relation of facts, I flatter myſelf, I have clearly ſhown that it cannot be ſupported as a general hypotheſis, that flowing lavas take a priſmatical configuration from the ſudden coagulation they ſuffer on falling into the ſea.

It may, perhaps, be objected, that theſe priſms once exiſted in the lavas I obſerved, but that the irreſiſtible violence of the waves, in a long ſeries of years, has corroded and deſtroyed them.

Every perſon acquainted with the ſubject muſt immediately perceive how little ſolidity there is in this objection. I admit that the violence of the ſea may, in ſome lavas,

lavas, have totally deſtroyed theſe priſms; but that it can have had that effect on all, and through ſo extenſive a ſpace, is utterly improbable. Nor is it conceivable that Felicuda, among the Eolian iſles, ſhould ſtill preſerve its priſms perfect, while the reſt of thoſe iſlands have entirely loſt theirs, notwithſtanding they are all equally expoſed to the ſhocks of the waves.

I cannot here omit another remark. It is certain that more than one of theſe iſlands were not formed by one eruption, but by ſucceſſive ejections of lavas accumulating on each other; and in ſome deep fiſſures, occaſioned by the ſea, this ſucceſſive formation is diſcoverable by the eye, as we may perceive five or ſix different ſtrata of lava one above the other. The internal ſtrata in very remote periods, having flowed into the ſea, as the external flowed afterwards; it is evident that, if the latter, on touching the water, became priſmatic, the ſame change muſt have taken place, alſo, in the former; which being defended

from the injuries of the ſea, by the external ſtrata, muſt ſtill preſerve their priſmatic configuration, of which, however, no traces remain. We muſt, therefore, conclude that innumerable lavas may fall into the ſea, without having their external appearance in the leaſt changed by the ſudden congelation which then takes place.

That the priſmatic configuration of lavas is not always the effect of their immerſion in the waters of the ſea, likewiſe appears from many of them taking the ſame form in the air; of which we have a diſtinguiſhed example in the crater of Vulcano. Here, certainly, we cannot ſuppoſe any intervention of the waters of the ſea. Similar obſervations have been made on Mount Etna by the Chevalier Gioeni. "I have obſerved," ſays he, in the work before cited, "baſaltic columns, at the "ſummit of Etna, and nearly on a level "with the baſe of its vaſt crater, where "there is certainly no probability of the "ſea ever having reached; and I have

"frequently

" frequently found polyhedrous baſaltes " perfectly characterized in excavations " made by men in the centre of lavas, " which have iſſued from the ſides of " Mount Etna, in periods much poſterior " to the retiring of the ſea."

I ſhould, however, appear deficient in candour, did I not mention that M. Dolomieu admits that lavas may ſometimes, in the air, aſſume the priſmatic form, if they fall into clefts and fiſſures where they ſuddenly cool, of which he adduces an example in the iſlands of Ponza.

I ſhall only remark, that I do not perceive the abſolute neceſſity of the fiſſures in this caſe; ſince we frequently find lavas with this configuration in perfectly open places; as I have ſeen in the great mouth of Vulcano. And with this opinion the obſervations of Gioeni on Etna certainly accord; for, had he remarked the concurrence of ſuch a circumſtance, he, undoubtedly, would have mentioned it.

What concluſion, then, ought we to deduce from all theſe facts and obſervations?

Firſt: that many baſaltiform lavas have aſſumed this organization on coagulating within the ſea.

Secondly: that others have taken the ſame form, merely in cooling in the open air.

Thirdly: that innumerable other lavas have not taken this figure, either in the ſea or in the air.

It appears, at firſt view, that theſe differences depend on the different nature of the lavas themſelves. This opinion, at leaſt, is rendered probable by what we obſerve in earths penetrated with water, which, in drying, take, more or leſs, priſmatic forms, as has been obſerved frequently in the argillaceous kinds. I have ſeen, when a turbid torrent has been introduced into a ditch through an argillaceous marle, the latter, in drying, divide into

into polyhedrous pieces; but when the water paſſed through chalk, or calcareous marle, the greater part of the pieces were amorphous. When we however obſerve lavas with requiſite attention, this conformation in them ſeems to be effected differently.

It has already been ſaid, that ſeveral of the priſmatic lavas of Felicuda have for their baſe ſhoerl in maſs; but it is true that other congenerous lavas of the ſame iſland, which form as it were walls perpendicular to the ſea, are ſmooth over their whole ſuperficies. A ſimilar ſmoothneſs is obſervable in ſome of thoſe of Mount Etna, on the ſhore between Meſſina and Catania, which have for their baſe the horn-ſtone; though others extremely reſembling them, between Jaci Reale and Catania, are formed in priſms.

Compactneſs and ſolidity are, likewiſe, not a neceſſary condition in lavas, to this appropriate cryſtallization. This has already been remarked by M. Dolomieu;

and I have obſerved that many amorphous lavas on the ſhores of ſeveral of the Eolian iſlands are more compact than the priſmatic lavas of Felicuda.

What then can be the intrinſic circumſtance of the lava which determines it thus to cleave in the priſmatic form? I confeſs I am ignorant: and who can ſay that we do not ſeek it in vain within the lava, ſince it may be extrinſic and adventitious? Such, certainly, appears to be the opinion of M. de Luc; and, more expreſsly, that of M. Dolomieu, who, to explain the phenomenon of volcanic priſms, has recourſe to a ſudden congelation, and inſtantaneous contraction of lavas.

The facts which we have adduced relative to lavas, both priſmatic and not priſmatic, it has been ſeen, do not always accord with thoſe related by the French naturaliſt. But even on this ſuppoſition, which is inconteſtable, may we not retain the ſame principle of explanation, which,

to ſay the truth, appears to be ſufficient, with ſome requiſite modifications? Theſe I will endeavour to ſuggeſt, illuſtrating my conjecture by the two caſes above adduced; the one, that of the lavas which take the form of priſms merely from the contact of the atmoſphere, as in Vulcano and near the ſummit of Etna; the other, that of the lavas which refuſe to take ſuch a form even within the ſea, as at Iſchia, in ſome parts of the baſe of Etna, and in all the Eolian iſles except Felicuda.

As to the former, may not a ſudden coagulation and contraction have taken place in ſome lavas from the mere influence of the atmoſphere, though the lava was not included in any cleft or fiſſure? It is ſufficient that it be ſuddenly deprived of the caloric (heat) by which it is penetrated, and which rendered it rareſied and fluid. To this deprivation a lava of little thickneſs will be very liable; ſince a body loſes its heat the ſooner, the leſs its thickneſs and denſity. This ſudden contraction

may alſo be produced by the circumſtances of the atmoſphere; as, ſhould a ſtrong wind, of a very cold temperature, blow at the time. The melted lavas in our crucibles will be found to give greater weight to this latter conjecture. If they are taken from the furnace, and cauſed to paſs through a heat gradually leſs; their ſurface, as they cool, will only ſplit in a few cracks, of little depth, and uſually irregular; but, when they are immediately, in the winter time, carried into the cold air, the fiſſures, beſides being deeper, will frequently be diſpoſed in ſuch a manner, as to form ſmall polyhedrous priſms, which may eaſily be detached from the reſt of the lava.

With reſpect to thoſe lavas which do not aſſume a priſmatic form though they fall into the ſea, it is certain that, to take that conformation, their maſs muſt have a ſtrong degree of effervescence and dilatation, and that it muſt be deeply penetrated with the igneous fluid, otherwiſe the contraction neceſſary

neceſſary to produce priſms cannot take place. But many currents which deſcend from the ſummit of burning mountains to the ſea, muſt have loſt their effervescence with their heat in ſo long a courſe, and ſcarcely contain ſufficient to continue their motion downwards, which, perhaps, would ceaſe, were it not for the impelling gravity of the lava, which frequently falls into the ſea perpendicularly.

Such is the hypotheſis by which I would explain the cauſe why ſome lavas have aſſumed a priſmatic conformation without any concurrence of the ſea-water, and others exhibit no appearance of it in places where they have immerged into the ſea. I nevertheleſs leave every one to form his own opinion; and ſhould an explanation of theſe important facts be diſcovered, preferable to mine, which I conſider as only conjectural, I ſhall receive the communication of it with ſincere gratitude, and adopt it with pleaſure.

CHAP. XX.

DIGRESSION RELATIVE TO THE DIFFERENT VOLCANIC PRODUCTIONS OF THE EUGANEAN MOUNTAINS.

Excurſion made to the Euganean mountains, by the author, during the vacations of 1789, *in order to compare the products of the volcanos he had viſited with thoſe of the mountains of Padua—Deſcription of different ſpecimens collected by him in this excurſion—Three kinds of lavas at Monte Caſtello—Erratic petroſilices mingled with them, of uncertain origin—Lavas of Monte del Donati, ſome with a petroſiliceous baſe, and others with a horn ſtone—Proof that one of theſe once formed currents—The accumulated priſmatic columns of Monte Roſſo have not for their baſe the granite, but the porphyry—Monte Ortone abounds in priſmatic lavas, but ſuch as are leſs characteriſed in their configuration—Lavas of Monte Merlo with a granitous baſe*

baſe—Black mica one of the component parts of this granite, which has the property of being attracted like iron by the magnet, a property poſſeſſed likewiſe by the other micas of the Euganean mountains—The micas of the primitive granites deſtitute of this property, but capable of receiving it by the action of fire—This important fact furniſhes a clear proof of the volcanization of the Euganean mountains—Nodoſities of quartz contained in this granitous lava, probably produced by filtration poſterior to ignition—The ſame obſervable of ſome ſhoerlaceous nodoſities included in it—The ſhoerls of the Euganean mountains act on the magnetic needle, like thoſe of other volcanic countries, and in that differ from thoſe which are not volcanic—Calcareous carbonates intermixed with the lavas of the Euganean mountains—Flints frequently found among theſe calcareous carbonates, which preſent the moſt ſpecious appearance of the change of lime into ſilex—Proof, by chemical analyſis, that it is not neceſſary to have recourſe to any ſuch change to explain this

this appearance—Strata of globes near Teolo abounding in particles of pitch-ſtone —Veins of pitch-ſtone lavas at Bajamonte and Sieva—Groups of pumices encloſed in one of theſe veins—Compariſon, in the dry way, of the non-volcanic pitch-ſtones with the volcanic—Proof, by the humid way, that both are of the ſame kind—Eſſential differences between the pitch-ſtone lavas and the volcanic glaſſes—Volcanic productions of Schivanoja, Monte Merlo, Maſcabo, Tremonte and Pendiſe, which have been ſtyled volcanic glaſs by a living writer, but which in reality can only be called pitch-ſtone lavas, and but one of them, at the utmoſt, a vitreous lava—Miſtake of this author in having taken for volcanic glaſs ſome pieces of glaſs from the furnaces of Murano, near Venice, which he caſually found in thoſe mountains—Remarks on this accident, which ſhould teach us to be cautious in forming a judgment whether a mountain be volcanic or not, from finding a detached piece of glaſs, or other production of the fire; ſince it may be uncertain

whether

whether that fire was volcanic or not—Poſſibility of being equally deceived by productions truly volcanic but erratic—Proof of this from a circumſtance which happened to the author—Little credit to be given to accounts intended to prove the exiſtence of ancient volcanos—Neceſſity that ſuch accounts ſhould be lithologically detailed—In what manner our judgments relative to lavas may be frequently miſtaken—Volcanic rocks may have the moſt ſpecious appearances of lavas, though they never formed currents—When other proofs are wanting, celluloſity the moſt certain indication that volcanic rocks have flowed in a ſtream—This celluloſity found in many Euganean lavas—Singularity of the feltſpars of a lava near Rua, which have, almoſt all, a portion of that lava for their central nucleus—Lavas of Galzignano, Pigozzo, Monte Nuovo, Monſelice, and Arqua—Singular lava of Monte Nuovo containing feltſpars become earth; and another at Monſelice containing pumices—Lavas of Catajo, one of which forms columnar

lumnar priſms—Reflections and corollaries —The Euganean mountains once were iſlands, like thoſe of Ponza, the Eolian, Santorine, &c.—Their prodigious antiquity, and vicinity to civilized places, two cauſes of the great changes they have undergone—Their lavas analogous to thoſe of other volcanos, in having rocks for their baſe—Compariſon between the rocks of other volcanos and thoſe of the Euganean mountains—Immenſe depth of theſe rocks, which would remain unknown to men were it not for volcanos—Three different baſes in the Euganean rocks, deſerving obſervation: the feltſpar in the maſs, the volcanized petroſilex, extremely reſembling the natural, and the pitch-ſtone—Volcanos which have not this ſtone, and others in which it is found more or leſs—Magneſia not one of the elements of the pitch-ſtone of volcanos, as ſome have thought—Intereſting obſervation of the change of petroſilex into pitch-ſtone—Chemical analyſis of theſe two ſtones agreeing with this obſervation—Probability that ſome volcanic pitch-ſtones

are

are derived from the non-volcanic—Our common fire equally vitrifies the Euganean lavas, and thoſe of other volcanos—Singular obſervation relative to the eaſy fuſion of feltſpars—Euganean baſaltes the products of fire—One of the ſtones of theſe mountains formed in priſms in one place in the dry way, and in another in the humid—Confirmation of the aſſertion, that it can only be determined by local circumſtances, which of the two modes Nature has employed in the conformation of baſaltes.

IN the year 1788, I preſented the Imperial Muſeum of Pavia with an ample collection of volcanic productions, from the two Sicilies; and afterwards formed the deſign of increaſing it, during the vacations of the following year, with others of the ſame kind from the mountains of Padua which had been extinct from time immemorial. This deſign I carried into effect with the aſſiſtance of a companion, than whom I could not have wiſhed for one better

better qualified to aid my reſearches; the Marcheſe Antonio Orologio, an accompliſhed gentleman, and well acquainted with thoſe mountains, as he has proved by ſeveral Eſſays replete with accurate and intereſting obſervations relative to them.

Having made ſeveral excurſions with this able guide, I examined the products I met with at my leiſure, and ſelected thoſe that appeared moſt ſuitable to my purpoſe; ſeveral of which I ſhall now proceed to deſcribe; as they are extremely well adapted to form a compariſon between the Paduan rocks and thoſe of other countries equally volcanic, which I viſited; as alſo to ſhew the nature of the modifications cauſed in both by fire; which comparative obſervations, I flatter myſelf, will not a little conduce to enlarge the ſphere of our knowledge reſpecting volcanos *.

I repaired,

* At firſt view, it may, perhaps, appear ſuperfluous that I ſhould ſay any thing on the Euganean products, as a *Deſcriptive Catalogue* has aleady been given of them by Sir John Strange. This naturaliſt has undoubtedly

I repaired, therefore, to Giara, in September 1789, to the delightful villa of the Marcheſe Orologio abovementioned, ſituated

doubtedly contributed much to the foſſil hiſtory of theſe mountains, the volcanization of which he firſt diſcovered and made known. We are likewiſe greatly indebted to him for the catalogue he has annexed, and which forms a kind of appendix, to his hiſtory. But, beſides that I frequently met with objects different from thoſe obſerved and deſcribed by him, the views with which we treated the ſame ſubject were entirely different. I propoſed to deſcribe lithologically, and thence to characterize, the Euganean products I met with in my excurſions, in the ſame manner as I have deſcribed thoſe of the two Sicilies: Sir J. Strange was ſatisfied with giving only ſimple indications of them; nor do I think I ſhall in the leaſt detract from the merit of this excellent author, if I ſay theſe indications were not always the moſt accurate; ſuch a defect being leſs imputable to him than to the time in which he wrote; ſince it is only within theſe few years that the mineralogy of volcanos has been ſtudied with preciſion and accuracy.

I ſhall take this opportunity to anſwer a queſtion which may be aſked; which is: Why, if I intended to give a lithological eſſay on the Paduan volcanoes, I did not mention it in the Introduction, where I enumerate the principal heads of the work. I reply that,

ated nearly at the foot of the Euganean hills, and proceeded with him, without delay, to make reſearches in them; examining firſt the ſtones of Monte Caſtello. This is a ſmall woody mountain, from which ariſe ſeveral rocky points adhering to the body of it, and affording three ſpecimens of lava.

The firſt has an argillaceous baſe, a coarſe grain, and blackiſh colour. It ſhines in many parts with black micaceous points, and is ſprinkled with reddiſh ſpots, like thoſe of feltſpar, in many oriental porphyries; and which are no other than ſcaly flakes of feltſpar, accompanied with a few black ſhoerls.

that, when I wrote that Introduction, I did not perceive the importance of the ſubject; and of ſeparating the obſervations I had made on other volcanoes from my remarks on the Euganean hills. I likewiſe, at that time, did not think it proper to mention this excurſion particularly, as the remarks I made in the courſe of it then remained unmethodized in my journals, and I feared that I might not find ſufficient leiſure to reduce them to order, as I afterwards was enabled.

The

The ſecond lava, which is of a light grey colour, might at firſt be taken for a carbonate of lime; but, when attentively examined in the recent fractures, its baſe is found to be a hard horn-ſtone, containing ſome black mica, and a few feltſpathoſe points.

The third lava, with ſome varieties little differing from it, has, in like manner, its baſe of horn-ſtone. Its colour is a pale grey, its paſte earthy, with an argillaceous ſmell; and, beſides numerous particles of black mica, it contains thick rectangular feltſpar lamellæ.

The ſhoerls, micas, and feltſpars of theſe three lavas, when fuſed in the furnace, are, together with the baſe, reduced to an enamellar and cellular ſcoria.

Though the three ſtones above deſcribed have not the appearance of having ever formed currents, nor the poroſity of ſome lavas, I do not heſitate to call them by that

name; not only becauſe they are integral parts of this volcanic mountain, but becauſe they appertain to a kind of ſtones of the Euganean hills, which, as will appear from facts hereafter adduced, bear evident marks of having ſuffered fuſion.

In the midſt of theſe lavas are found pieces of petroſilex of a very fine grain, which, as they are detached and ſcattered, I am unable to ſay whether they have been affected by the fire, or thrown out untouched by ſome volcano. All of them contain cryſtallizations of micas, ſhoerls, and feltſpars; and theſe cryſtallizations fuſe in the furnace together with the petroſiliceous baſe.

From Monte-Caſtello I proceeded to the neighbouring mountain Donati. At the top it has a double ſummit; and both there and at the baſe, having broken off ſeveral pieces from the ſtony maſs of the mountain, it appeared to me that the lavas of which it is compoſed may be reduced to two

kinds—lavas with a petroſiliceous baſe, and lavas with a horn-ſtone baſe. The former have a ſmooth, and, ſometimes, conchoidal fracture, a fine and compact texture, and contain a conſiderable quantity of ſhoerls and rhomboidal feltſpars. The glaſs produced from them in the furnace is white, with a complete fuſion of the above-mentioned cryſtallizations.

The lavas with a horn-ſtone baſe are ſoft; all emit an argillaceous ſmell, have an earthy texture, and, for the moſt part, abound in feltſpars, cryſtallized ſhoerls, and black hexagonal micas. One of theſe lavas bears the moſt evident marks of having flowed. It is full of ſmall pores and vacuities, not only on the ſurface but in the internal part. Theſe vacuities are of different ſizes, from thoſe that can only be diſcovered with the microſcope, to thoſe half an inch in breadth. Many of them are oval, and the longer diameter is almoſt always placed in the ſame direction. This obſervation is of conſiderable importance; firſt, becauſe it

ſhows that this rock was once fluid from the action of the fire ; ſince otherwiſe theſe innumerable vacuities would not have been produced ; and, ſecondly, that it has been in motion, in conſequence of which the bubbles, naturally of a round figure, have taken a form more or leſs oblong. The truth of this deduction is confirmed by what has been obſerved in many of the lavas of Lipari. Some of theſe cavities are filled with cryſtallized carbonate of lime.

This lava is likewiſe remarkable for the large ſize of the ſhoerls it contains ; ſeveral of which are ten lines in length, and ſome even an inch. They are of a black colour, have a ſcaly fracture, and facets of ſo lively a luſtre, that they may compare with the moſt beautiful cryſtals of ſpecular iron. Both when detached, and when incorporated with the lava, they melt, in the furnace, into a black, compact enamel, giving ſparks copiouſly with ſteel, and of a luſtre little inferior to that of the ſhoerls themſelves. Fuſion ſucceeds equally in the other

lavas

lavas of the horn-ſtone baſe, with the vitrification of the ſhoerls, feltſpars, and micas.

From Monte del Donati I proceeded to Monte Roſſo, celebrated for its maſs of priſmatic columns. The firſt naturaliſt who pointed them out was Ferber; they afterwards were deſcribed by Sir John Strange *, who obſerved that they are almoſt perpendicular to the horizon, and parallel to each other; that they differ in form and ſize, and ſeem intimately connected with the ſtony body of the mountain. On examining them, I found the obſervations of the Engliſh writer perfectly accurate; but I cannot refrain from making a few remarks on the nature of this columnar aggregate which he calls granitous. Both in the internal part and on the ſurface of theſe priſmatic columns, felt-

* Opuſc. Scelt. di Milano, t. i. in 4to. This deſcription was read to the Royal Society in 1774, and is inſerted in the *Philoſ. Tranſact.* vol. lxv. part i. for 1775. T.

ſpars, mica, and ſhoerls, are very conſpicuous to the eye. The ſhoerls are rhomboidal priſms, a line, or two lines, in length, at the moſt, and about half as broad, ſemitranſparent, of a whitiſh colour, ſhining but little on the ſurface, but very conſiderably in the fractures, and with a luſtre of changeable colours. The mica is, for the moſt part, black; but ſometimes of a golden yellow, and in flat, hexaëdral, opake, laminous, and extremely lucid priſms, the largeſt of which are little more than a line in length. Theſe two ſtones are rather numerous; but the ſhoerls, which are, for the moſt part, linear, are but few. They are all three contained in a petroſiliceous paſte, become earthy by decompoſition, and, at the ſurface of the priſmatic columns, almoſt pulverulent, and of the colour of a dead leaf; but internally it preſerves the character of the petroſilex, giving ſparks more or leſs with ſteel, and being of a dark colour. The furnace converts theſe columns into an enamel inclining to a black colour,

colour, with few but large bubbles ; a fuſion takes place in the ſhoerls, but not completely in the feltſpars.

From this deſcription we perceive that this maſs of columns cannot properly be called granitous ; the generality of naturaliſts, and the moſt reſpectable chemiſts, agreeing that by the term granite is underſtood a rock or ſtone compoſed of two or more ſubſtances, frequently cryſtallized and united together without the appearance of any connecting ground or cement. But here the ſhoerls, the mica, and the feltſpars are enveloped in a petroſiliceous paſte ; whence we ought rather to denominate theſe columns porphyritic. The ſame is true of the remaining maſs of Monte Roſſo, which is almoſt entirely formed of the ſame rock.

Under this baſaltiform group we find numerous globes of the ſame rock, which I judge to be pieces of priſms that have fallen down and become round by the eroſion of

their angles, in conſequence of the decompoſition they have ſuffered by time and the humid elements; as it cannot be ſuppoſed that their globular figure has been produced by their being rolled by the waters, ſince there is here no trace of either river or torrent, and their decompoſition is, beſides, very conſiderable.

Monte Roſſo is an iſolated mountain, about a mile and a half in circumference. On one ſide of it, there is at its foot an excavation which the Benedictine Monks of Praglia cauſed to be made, to obtain ſtones, but which has been for ſome time abandoned. The ſides of this cavity exhibit very apparent priſms; though not ſo perfectly characterized as thoſe before deſcribed. Should other parts of the mountain be dug into, it is probable that other groups would be diſcovered.

This certainly is not the only place productive of theſe figured ſtones; for we find prodigious maſſes of them at Monte Ortone,

tone, rudely formed, it is true, but very diſtinguiſhable. They conſiſt of a lava of a cinereous grey colour, of a petroſiliceous baſe, and marked, in many parts, with thin reddiſh ſtreaks parallel to each other. A conſiderable number of rhomboidal, ſhining, and tranſparent feltſpars, and a few black, hexagonal particles of mica are contained in the baſe of this lava, which changes in the furnace into a dark grey enamel, with the fuſion of the feltſpars and the micas. In ſeveral parts of the mountain, when we dig into it, we find imperfect priſms; and they frequently project out near the ſummit, and on the ſides; as we may obſerve in the road leading to Praglia. The mountain is formed of this lava, which, on the ſurface, is decompoſed and become earth, in which a number of olive-trees grow and thrive. A ſimilar decompoſition is obſervable at Monte Roſſo, the earth of which is, in a great meaſure, a mixture of fragments of micas, feltſpars, and ſhoerls.

The

The Euganean mountains, which form maſſes, for the moſt part conical, ſome detached, and others contiguous at their baſes, are principally compoſed of lavas, with which, in ſeveral of them, are mixed calcareous carbonates. Theſe two kinds of ſtones are of ſome value to the Venetians, who uſe the lavas, which they call *maſegne*, to pave the ſtreets, and the carbonates to make lime. There are therefore here ſeveral quarries, ſome of which are now worked, while others, that are either exhauſted, or become leſs productive, are abandoned.

I entered two of theſe quarries, the one at Monte Roſſo, and the other at Monte Ortone; and, having continued there ſome time, determined to go down into ſome others, as I found they were extremely convenient for obſerving in their ſides the ſtony ſubſtances I wiſhed to examine. I therefore proceeded to Monte Merlo, where there is a very large excavation of this kind within the lava. To extract the ſtones, which

which are very hard, the labourers have recourſe to the following dangerous method. A man, faſtened by a rope, is let down to a certain depth againſt the perpendicular ſides of the cavern; and, the other end of the rope being made faſt at the top, breaks the ſtone in pieces with pickaxes, availing himſelf of certain vertical fiſſures, which greatly facilitate the labour. Mines are likewiſe prepared, in ſome caſes, which blow the fragments of the ſtone into the air.

In this excavation, and in another of leſs dimenſions, not far diſtant, the lava of the mountain is truly granitous, and the granite has for its baſe the feltſpar, which is ſo abundant that it compoſes the greater part of the rock. It would be ſuperfluous to deſcribe it, as it is perfectly ſimilar, even in its cryſtallization, to that of Monte Roſſo and Monte Ortone. Beſides the feltſpars, which, by their brilliancy and other excluſive characters, immediately declare their nature, certain white ſpots preſent themſelves

ſelves to the eye, which at firſt view may excite a doubt to what kind of ſtones they appertain; but, when examined attentively and under different reflections of the light, we are convinced that they are true felt-ſpars, but in part calcined. Theſe feltſpars are accompanied with the uſual hexagonal micas, and ſome ſhoerlaceous points.

This granite, liquefied by the volcanic fire, reminds me of the great activity requiſite in our common fires, for the fuſion of granites that are not volcanic, and even of thoſe which are; as I have ſhown in Chap. XII. I have ſince thought that poſſibly ſo great a degree of heat was not neceſſary in the preſent inſtance, from this granitous lava being deprived of quartz, one of the elements of the granites on which I made my experiments, and which certainly is that among them moſt refractory to fuſion. I have found, in fact, that this lava, when continued a long time in the furnace, affords a vitreous product of a black colour, and nearly homogeneous,

ſome

ſome feltſpars only being perceivable in it in the form of white ſpots.

I have ſaid, a little above, that black mica is one of the component parts of this granite. I ſhall here add, that when it is detached from the volcanic rock and approached to the magnet, it will adhere to it like a particle of iron; which property it ſhares with other black micas, before deſcribed, and with almoſt all I ſhall hereafter have occaſion to mention. This curious phenomenon was pointed out to me at Venice, before I made my excurſion to the Euganean mountains, by that excellent naturaliſt Sig. Giovanni Arduino. The greater part of the ſtreets of that capital are paved with theſe Paduan ſtones, and it was in ſome of them I was ſhown this quality by Sig. Arduino. He, indeed, was of opinion that theſe ſhining black particles were rather particles of iron than of mica; but ocular examination convinced me that they appertain to this ſtone; ſince with the lens we may perceive that they conſiſt of delicately

thin

thin and ſemitranſparent laminæ, which, when touched with the point of a needle, are found to be flexible and elaſtic, and ſeparate from each other. In the fire, as has been ſaid, they vitrify, and the glaſs produced from them is of a blackiſh colour, and ſemitranſparent.

The magnetic property of theſe micas, among the many I have examined, I have found in none which enter into the compoſition of granites not affected by the fire. In my return by land from Conſtantinople to Italy, I collected ſpecimens of the ſtones compoſing the mountains over which my road led me, and, among others, of a conſiderable number of granites, which, from the nature of the places where they were found, were certainly not volcanic. Many more I found in the Alps, and other countries not volcanic. On the micas they contained I made experiments with the magnet; but I did not find one, whatever was its colour, which ſhowed the leaſt ſign of attraction. In ſeveral of them, indeed, I found

found it after they had been expoſed for ſome time to the fire. This excluſive property of the Euganean micas is therefore a proof that they have felt the influence of this agent, and is a ſtrong confirmation of their volcanization.

Before I diſmiſs the quarries of Monte Merlo, I ſhall briefly ſtate two facts not undeſerving the attention of the reader. Firſt, it is not unuſual to find within the granitous lava nodoſities of pure quartz, of the thickneſs of one, two, and ſometimes even five inches. Beſides giving ſparks plentifully with ſteel, which is the peculiar property of this ſtone, it has a colour lightly amethyſtine; it is tranſparent, ſomewhat unctuous to the touch, ſolid, and of an indeterminate figure. But to what are we to attribute the exiſtence of theſe quartzoſe nodoſities, which are uninjured, within this volcanic granite? I cannot perſuade myſelf that they exiſted in it previous to its ignition; ſince, had this taken place afterwards, it muſt have altered the quartz, by depriving

depriving it of its tranſparency, and rendering it full of cracks, and extremely friable; all which changes follow on expoſing it a ſhort time to the furnace. I ſhall obſerve, further, that two of theſe nodoſities being left in a crucible placed on burning charcoal only for a quarter of an hour, loſt their amethyſtine colour, and acquired a more than ſuperficial whiteneſs, with a number of cracks, and very apparent friability. I, therefore, cannot believe that they have been taken up by the way, and enveloped in the lava when it flowed, as ſometimes happens, when fiery torrents meet with extraneous ſtones in their paſſage. I am, in fact, of opinion, that theſe ſmall maſſes of quartz have been produced poſterior to the congelation of the lava, by the filtration of water impregnated with the molecules of quartz, which has penetrated into ſome ſmall cavities, and gradually filled them; in the ſame manner as we have explained the formation of the calcedonic globes found in ſome of the lavas of Lipari *.

* See Chap. XV.

The

The other fact is very ſimilar to this, and may be explained in the ſame manner. It relates to the large pieces of ſhoerl which are contained in this volcanic rock, and are diſcovered on its being broken into pieces, in the ſame manner as the quartz. Theſe are compoſed of a number of rhomboidal ſhoerlaceous priſms, ſo confuſedly heaped and joined together, that it is impoſſible to obtain a ſingle priſm entire. Excepting in the largeneſs of their ſize, they perfectly reſemble thoſe of the porous lava, with the horn-ſtone baſe, of Monte Donati, of which we have ſpoken above. Theſe ſhoerls, like all the others of the Euganean mountains, concur to prove the volcanization of the latter, by the ſame property which is found in the black micas of this country; I mean their magnetiſm. Baron Dietrich, deſcribing the volcanos of Old-Briſach, ſhews that the action on the magnet of the black cryſtallized ſhoerls, is the excluſive property of thoſe that are volcanic. Though, in the courſe of this work, I believe, I have only mentioned the ſhoerls of Monte Roſſo, at

Etna, as poſſeſſing the property of ſtrongly moving the magnetic needle*, I did not fail to make the ſame examination relative to numerous ſhoerls of the Phlegrean Fields and Eolian Iſles, and can poſitively affirm that I found this quality in them all. It is at the ſame time to be obſerved, that I could not perceive it in eleven ſpecies of ſhoerls, whatever was their colour, ſome of which were detached from granites, and others found ſolitary. This obſervation, when treating of the Euganean mountains, appears to me too important to be omitted.

Theſe ſhoerlaceous lumps or groups, I am of opinion, muſt have been produced in the granitous rock by filtration, with this ſingle difference, that the quartzoſe groups have remained amorphous, and the ſhoerlaceous are confuſedly cryſtallized; probably from the more ready tendency of the integrant molecules to take a determinate form.

* See Chap. VII.

Having

Having examined ſome of the quarries which furniſh volcanic ſtones, I proceeded to viſit thoſe where carbonate of lime is dug, of which ſtone there is no ſcarcity in the Euganean mountains. Such are the quarries of Battaglia, Fraſſinelle, and Saint James, ſituated on the declivities of the Monte Grande, above Teolo. Before we reach the lava of Battaglia, we meet with this carbonate. It is ſciſſile, and eaſily divides in flakes, for the moſt part, horizontal. This quarry is very large, and in ſome places forty-five or fifty feet deep. It principally conſiſts of this ſtone, which is excellent for making lime. The lime-ſtone is diſpoſed in ſtrata of different thickneſs; from thoſe of one inch or leſs to thoſe of a foot. We ſeldom meet with ſtony ſtrata which preſerve ſo well their paralleliſm to each other, and to the horizon. In the midſt of the carbonates are found numerous flints, or fire-ſtones, already well known from the mention made of them by other writers; for the Euganean mountains, wherever they afford calcareous carbonates, con-

tain likewiſe flints. On examining thoſe of the quarry of Battaglia, I found ſeveral of them ſo cloſely united with the calcareous carbonate, as to preſent the moſt ſpecious appearance of a tranſmutation of the lime into ſilex. But to give a clearer idea of this apparent tranſmutation, it will be neceſſary to deſcribe both the carbonate of lime and the flint.

The lime-ſtone is white, compact, not very heavy, compoſed of impalpable particles, ſoft to the touch, with a ſmooth and ſometimes conchoidal fracture, and breaking into obtuſe and amorphous fragments. It is diſſolved by acids with conſiderable effervescence. Both internally, and on the ſurface of this white ſtone, black, dendritic, and not inelegant ſpots and ſtreaks are very conſpicuous.

The flint is of a deep fleſh-colour, ſometimes brown and even black; its grain is extremely compact and fine; its fracture ſmooth, and almoſt always conchoidal, and its

its fragments angular, acute at the extremities, and ſemi-pellucid. It is more than moderately heavy, the file will not touch it, and it gives ſparks ſtrongly with ſteel. Notwithſtanding their great hardneſs, however, the generality of theſe flints eaſily break into ſmall pieces under the hammer. Some of them, in the quarry of Battaglia, are placed between the ſtrata of the carbonates of lime; but they frequently alſo form a continuation with them; ſometimes, indeed, divided by a ſudden and abrupt ſeparation, but frequently, likewiſe, by inſenſible gradations; in which latter caſe there is a ſpecious appearance of an inſenſible tranſition of the lime into ſilex; and the opinion that this is really the fact has been adopted by many.

A piece which exhibits this appearance has one part of it white; which colour inſenſibly diſappears, and is ſucceeded by a reddiſh tinge, that gradually increaſes till the remainder of the piece at length aſſumes the red, brown, or black colour which is

proper to this flint. The change of colour is accompanied by a difference in the hardneſs, which ſucceſſively increaſes, as appears from its ſcintillation with ſteel; the white part of the ſtone yielding no ſparks; the light red, very few; but the deep red, or black, affording them plentifully. If a ſtream of nitric acid be poured from one end to the other of ſuch a piece, where the colour is white an effervescence ariſes, which becomes leſs ſenſible in the pale red parts, diminiſhing as that colour increaſes, until no appearance of it is diſcoverable where the redneſs is deepeſt, and the ſcintillation with ſteel ſtrongeſt. Theſe characters, however, to the chemical eye are not deciſive of the fact in queſtion. For, not to mention that difference of colour never conſtitutes a diverſity of ſpecies in either of the three kingdoms of Nature, the properties of hardneſs, and giving ſparks with ſteel, do not exclude the preſence of carbonate of lime; ſince, though it has been conſidered as the diſtinguiſhing property of calcareous carbonates, that they do not afford

ford ſparks with ſteel, it has been proved that there are ſeveral which have this quality. I poſſeſs ſeveral ſpecimens of marbles, that I collected ſome years ſince in the quarries of Carrara, which when ſtruck againſt ſteel afford no inconſiderable quantity of ſparks. The ſame may be ſaid of the effervescence with acids, there being ſeveral kinds of theſe carbonates in which acids cauſe no motion, though they ſufficiently diſſolve them.

To obtain proofs leſs equivocal, whether this tranſmutation really took place, I reſolved to have recourſe to chemical analyſis, making my experiments on fragments of the ſame piece, ſome entirely white, others of a very light red, others ſtill redder, and others of a deep red. The reſults were as follow:

In the fragments of the firſt kind, I found the quantity of lime very great, and that of ſilex very ſmall; neglecting, at that time, the carbonic acid gas, and the ſmall

portion of alumine. In thoſe of the ſecond, the quantity of lime was great, and that of the ſilex moderate. In the third, the portion of the lime was moderate, and that of the ſilex large. In the laſt, the quantity of ſilex was very great, and that of the lime ſmall.

From theſe facts it appeared to me evident, that it was not neceſſary to have recourſe to an imaginary tranſmutation, ſince the gradations in the ſame ſtone above deſcribed might be explained without it. Thoſe flints which make a part of the ſame ſtratum with the calcareous carbonates, ſhew that they were formed at the ſame time with them; that is, when they were produced by the numerous ſediments of the ſea-water loaded with calcareous mixed with ſiliceous particles. When the latter were abundant in the ſame place, they united by the force of affinity; forming, by their precipitation, ſiliceous ſtrata continued with calcareous; and when the ſiliceous particles were few in proportion to the calcareous, they united with

with the latter, generating mixtures of the two earths ſuch as they have been found when analyſed.

It muſt, however, be obſerved, that not unfrequently they have not an immediate connexion with the calcareous carbonates; but are only found under them in the form of globes and lenſes inveſted externally with that light grey cruſt which is obſervable in a multitude of other flints. It is very poſſible that the production of theſe globes and lenſes may be poſterior, and cauſed by filtration, after the formation of the calcareous ſtrata.

I ſhall ſay nothing of other quarries of lime-ſtone ſituated in other parts of the Euganean mountains, nor of the flints they contain, as they do not eſſentially differ from the quarry above deſcribed.

But to return to the ſtones which derive their origin from fire, I ſhall now proceed to ſpeak of a kind of lava, the moſt noble and

and beautiful which any volcanos afford. Near Teolo riſes a ſmall hill, called the Monte del Boldu, principally compoſed of ſtony globes of various ſizes, diſpoſed in ſtrata, tenaciouſly adherent, with a central nucleus. Theſe globes are of an iron colour, and ſprinkled over in every part with lucid points, which at firſt view I imagined micaceous; but, on examining them attentively, I diſcovered they were ſo many particles of pitch-ſtone, the *pechſtein* of the Germans. When viewed in a bright light, they appear white, ſome more and ſome leſs, and all have a degree of tranſparence. They are rather mechanically united than combined with a granular baſe, which appeared to me a ſoft horn-ſtone. The furnace changes theſe globes into an enamel, as black and opake, as it is ſolid and compact.

What I obſerved in this lava induced me to hope that in ſome other part of the Euganean mountains I might find a pure pitch-ſtone lava; which I, in fact, afterwards

wards diſcovered, in a ſmall valley, to the ſouth, below Bajamonte. It there forms a vein about thirty-five feet long, and nine and a half broad. On the ſurface it is ſo much decompoſed, that it will crumble between the fingers. At a little depth it is leſs ſoft, but always retains a conſiderable degree of friability. The pieces into which this vein breaks frequently take an oval form, which they likewiſe have when broken into ſmaller pieces. To render more apparent the colour of this ſtone, it is proper to wet it; for wetting is to rough ſtones a kind of half poliſh. It then has the exact appearance of the pitch-ſtones. In ſome parts it is of a red colour; ſometimes pale, ſometimes more lively, and ſometimes inclining to a yellow; in which latter caſe, it reſembles certain kinds of amber; but in other parts the colour is a mixture of blue, green, and white, but all of them very pale. The fractures are always amorphous, of unequal ſurface, and little brilliancy. The thinner flakes are tranſparent; as is the property of ſome pitch-

pitch-ſtones. This lava contains unequally diſtributed feltſpars of a flat form, friable, and not very brilliant. Every ſtroke with the ſteel breaks off ſome pieces, but extracts no ſparks.

A few hours in the furnace deprive this ſtone of its colours, rendering it of an aſh grey: it likewiſe loſes its friability and ſoftneſs, and becomes capable of giving ſparks with ſteel; reſembling then a paſte of porcelain. Continuing the heat longer, the cinereous colour remains, with the appearance of very numerous bubbles; and the lava paſſes into a homogeneous veſicular enamel, with a fuſion of the feltſpars.

The ſmall valley of Bajamonte is not, however, the only place in which this pitch-ſtone lava is found; it is met with in ſeveral others; as at Monte Sieva, and its environs. We there find banks or veins inclined in different angles to the horizon, and ſometimes perpendicular to it. The lava of one of theſe has exactly the

colour and luſtre of pitch, and contains numerous feltſpars. In its external appearance it does not differ from that before deſcribed. It has, however, one peculiarity which muſt render it valuable in the eyes of the volcaniſt.

Pumices are a kind of products which bear in them, demonſtratively, the evidences of fire; and the traveller who on any mountains meets with a vein of uncertain origin which paſſes immediately into the ſtate of pumice, is fully warranted to declare it volcanic. This is the caſe in the preſent pitch-ſtone. It contains groups, more or leſs large, of fibrous, light, cellular pumice, not merely contained within it, but compoſing one ſingle body with it: whence it appears that ſome parts of this rock, either by a more violent action of the fire, or becauſe they were more eaſily vitrifiable, have paſſed into the ſtate of pumice.

In the ſame Monte Sieva, beſides a lava with

with a petroſiliceous baſe, which, from its compactneſs, extremely reſembles the natural petroſilex, but which is fuſible in the furnace, we find another vein of pitch-ſtone lava, but of much greater extent, and which is diſpoſed almoſt vertically. On digging into this vein, we find very beautiful and well preſerved pieces of pitch-ſtone lava. For the moſt part it has the colour of reſin, an elegant luſtre, a fine grain, and great compactneſs. It is ſmooth and clear in the fracture, with amorphous fragments, ſemi-tranſparent in the points. It is not, however, ſufficiently hard to give ſparks with ſteel. It is not without felt-ſpars, which have a vitreous aſpect.

This lava does not entirely compoſe this extenſive vein; but is found there in pieces, uſually ſmall, which are cloſely bound together by a ſtony ſubſtance which acts with reſpect to them as a gluten or cement. Theſe pieces have not been rolled by a ſtream or waves, and thereby become round, but are amorphous, and with acute angles.

angles. It is evident, therefore, that this lava has been broken by ſome violent agent; and its pieces afterwards have been taken up, and incloſed within the ſtony ſubſtance, which, when carefully examined, is found to be only a conglutination of very fine duſt of the ſame pitch-ſtone; which alſo contains ſtones of ſeveral other kinds.

At Cataio, where is the villa of the Marcheſe degli Obizzi, are large excavations in the ſide of a mountain, made in the ſame brecciated pitch-ſtone. We here, likewiſe, find only very ſmall, but numerous, fragments of this ſtone bound together, in like manner, by a congenerous ground.

In another part of this mountain the ſame ſtone again appears; it does not, however, reſemble a breccia, but forms thin veins, and is extremely ſimilar to that of Bajamonte.

The experiments which I made in the furnace on the firſt ſpecies of lava I repeated

on

on the others; not excepting the baſe of thoſe I have termed breccias; and I obtained from them the ſame kind of grey and cellular enamel.

I have called the lavas now deſcribed pitch-ſtone lavas, becauſe they reſemble in their external appearance the ſtone deſigned by that name. I have likewiſe the authority of M. Dolomieu, who treating of lavas found by him in the Paduan mountains, and in the iſlands of Ponza, gives them that denomination. He aſſerts, however, that the lavas differ from the pitch-ſtone in a peculiar property, which conſiſts in the extreme eaſe with which the volcanic pitch-ſtones may be fuſed, and the infuſibility of the true pitch-ſtone even in a violent fire *.

Having obtained a number of pitch-ſtones that were not volcanic, I determined to make experiments on them in the fur-

* In his Notes to Bergmann's Diſſertation on Volcanic Products.

nace.

nace. They were, in the whole, nine: three from the iſle of Elba; one cineritious and almoſt opake; the ſecond ſemitranſparent and yellowiſh; and the third opake and inclining to black: three from Germany; the firſt yellow, the ſecond red, the third black, and all opake: the three laſt from the Pyrenees; one reddiſh, the other green, and the third of a colour between a green and a pale blue; and all three ſomewhat tranſparent in the angles. The firſt ſix, after having continued forty-eight hours in the furnace, ſhewed no ſign of liquefaction; but only became white, extremely light, and pulverable under the finger. Thoſe of the Pyrenees were changed into a beautiful white enamel, giving ſparks with ſteel, and full of minute bubbles. The pitch-ſtones of Saxony, which are found in places not volcanic, are eaſily fuſible in a not very ſtrong fire, as Delametherie has obſerved.

Several analyſes have been made of pech-ſtein or pitch-ſtones. In one, Berg-

mann found the portion of ſilex to be greateſt, that of alumine, little, and that of lime, leaſt.

Another, analyzed by Wiegleb, gave

Silex - - -	65
Alumine - - -	16
Iron - - -	5

The other 14 parts requiſite to complete the 100 were diſperſed in the operation *.

A third by Gmelin

Silex - - -	90
Alumine - - -	7
Iron - - -	3

The pitch-ſtone lavas of the Euganean mountains having never to my knowledge been analyſed, I undertook this operation on the three ſpecies mentioned above; and the following were the reſults:

* Kirwan's Mineralogy.

Pitch-

Pitch-ſtone lava below Bajamonte,

Silex - - -	71
Alumine - - -	18
Lime - - -	4
Iron - - -	5

Pitch-ſtone lava of Monte Sieva in beautiful and well preſerved pieces,

Silex - - -	$73\frac{1}{2}$
Alumine - - -	14
Lime - - -	8
Iron - - -	$3\frac{1}{3}$

Pitch-ſtone lava of the ſame Monte Sieva, ſerving as a cement or baſe to the above pieces,

Silex - - -	$68\frac{3}{4}$
Alumine - - -	19
Lime - - -	8
Iron - - -	2

When theſe three analyſes of mine of the volcanic pitch-ſtones of the Paduan mountains are compared with thoſe of Bergmann, Wiegleb, and Gmelin, we ſhall

find that the principle moſt abounding in theſe ſix ſtones is the ſilex; that the alumine is but in a moderate or ſmall proportion; as are likewiſe the lime and iron when they enter into the compoſition of theſe ſtones. It is therefore evident that theſe ſix ſtones are of the ſame ſpecies; nor can the infuſibility of ſeveral pitch-ſtones, which are not volcanic, diſtinguiſh them as eſſentially different from the volcanic, ſince we find in the genus of petroſilices ſome which fuſe in the furnace while others remain refractory. It is, beſides, not invariably true that volcanic pitch-ſtones are eaſily fuſible. Thoſe of Monte Muſſato, of which I ſhall preſently treat, require a continuance of ſeveral days in the furnace before they are completely fuſed. Some pitch-ſtone lavas of the iſlands of Ponza, which are of a pale white colour, and of a ſmooth and ſhining fracture, after continuing ſeveral hours in the furnace, only become of a deep red colour, and fuſion does not take place till after thirty hours. It is remarkable that almoſt all volcanic

canic pitch-ſtone lavas, whatever may be their colour, as ſoon as they are expoſed to our common fire, become red.

Theſe pitch-ſtone lavas, which are found in other parts of the Euganean mountains beſides thoſe already mentioned, have induced Father Terzi, a Benedictine, to ſuppoſe that they were no other than real glaſs, an opinion which he publiſhed a few years ſince in ſome letters on the Euganean products. He informs us that he diſcovered large veins of them in the Monte del Muſſato, and at Brecalon, as well as in other places. The novelty of the diſcovery greatly excited the ſurpriſe of many Paduan naturaliſts, and eſpecially of the Abbé Fortis, who having frequently made excurſions to theſe mountains to examine their products, could never meet with this extraordinary glaſs. To aſcertain the truth, he, with ſome other perſons well acquainted with this branch of natural ſcience, repaired to the mountains, and ſoon diſcovered the error which had been committed by the good Father miſ-

taking theſe pitch-ſtone lavas for glaſs, which error he detected and proved in a Memoir entitled *On certain parts of the Paduan Mountains* *.

In September 1792, the Marcheſe Antonio Orologio and myſelf, having made an excurſion to the Euganean mountains, to viſit this celebrated naturaliſt, who reſided at the village of Galzignano, he conducted us to Monte del Muſſato, where theſe ſuppoſed veins of glaſs were to be ſeen; but we found that they were only large maſſes of pitch-ſtone lava, ſimilar to that above deſcribed; of which I was ſtill more convinced afterwards, as I took ſome ſpecimens from the ſpot and carried them with me to Pavia. This pitch-ſtone lava is of two kinds. The one is interrupted with thin ſtreaks of a white earth, which attaches to the tongue and emits an argillaceous ſmell, and by which the lava often appears as if divided in ſmall pieces; it alſo, in

* Sopra parecchie località de' Monti Padovani.

many

many places, includes extraneous bodies, ſome of which are of conſiderable importance to volcanic enquiries. Theſe are ſmall pieces of horn-ſtone poſſeſſing that poroſity which characterizes them for true lavas. One of the ſpecimens above mentioned contains a fragment of this kind two inches in thickneſs, extremely perfect, and very porous. The vacuities are round and elliptical: ſatisfactory ſigns that it has made a part of ſome current.

The other lava from the ſame mountain reſembles the former, as far, at leaſt, as can be judged from the ſpecimens I brought away, in its colour, which is that of turpentine, only much darker and leſs lively: and in its conſiſtence; except that it forms unmixed maſſes, and contains amorphous feltſpars, of little or no brilliancy. Among all the pitch-ſtone lavas of the Euganean mountains that fell under my obſervation, this is the moſt compact, heavy, and hard. The eye alone, however, is ſufficient to diſcern the great difference between theſe

pitch-ſtone lavas and volcanic glaſs. The idea of volcanic glaſs is derived from that we have from our common glaſſes; the inſeparable characters of which, as we well know, are, that they ſhould have a ſhining and bright ſurface; be compoſed of indiſcernible particles; break into angular pieces, extremely thin at the edges, and with acute and piercing points; with a fracture either entirely ſmooth and clear, or, as we frequently find, with waving and curved ſtreaks; not to mention its tranſparency, a quality known to every one, and, in glaſs, one of the moſt valuable. The ſame, preciſely, are the characters of the greater part of volcanic glaſſes; but the deſcription of the pitch-ſtone lavas is very different. They have commonly a dead and dull luſtre; their paſte is fine, indeed, but not comparable in fineneſs to that of glaſs; they are leſs ſmooth in the fractures, leſs ſharp and cutting at the edges, and have little or no tranſparency. They are likewiſe diſtinguiſhed by another property from volcanic glaſſes, the greater part of which are ſufficiently

ciently hard to extract ſparks from ſteel, that is to ſay, to melt it: on the contrary, I was never able to extract the ſmalleſt ſpark from the pitch-ſtone lavas above mentioned, though I made the experiment on them with the beſt ſteel. They are therefore leſs hard than volcanic glaſs, as is indeed apparent from the facility with which pieces fly off at every ſtroke. To theſe evident diſſimilarities we may likewiſe add the weight, which in pieces of the ſame ſize is always greater in volcanic glaſs than in pitch-ſtone lavas.

Father Terzi may, however, eaſily convince himſelf that thoſe veins of the Euganean mountains which he calls glaſs, are by no means entitled to that appellation, if he will fuſe a ſmall portion of them in the furnace. He will then find the product a true enamel, exhibiting a vitreous aſpect not at all diſcoverable in the pitch-ſtone lava from which it was produced. This is true, likewiſe, of the veins of Monte Muſſato; and ſhews that the pitch-ſtone lavas muſt not only

only be excluded from the claſs of volcanic glaſſes, but even from that of enamels.

When, in the year 1789, I made an excurſion over the mountains of Padua, in ſearch of volcanic objects, accompanied by the Marcheſe Orologio, we, at Praglia, were received and moſt hoſpitably entertained in the ancient and magnificent monaſtery of the Benedictines by the excellent Father Terzi, who, after dinner, took us into his private cabinet of volcanic-marine products, collected on the Euganean mountains. He preſented us likewiſe with ſome ſpecimens, informing us at the ſame time where they had been found, which I think deſerving of a particular deſcription.

The firſt, which, according to the account he gave us, was brought from Schivanoja, is a mixture of amorphous, white, and friable feltſpar, and black, priſmatic, and extremely brilliant ſhoerls, much reſembling ſome ſpecies of tourmalins. From this mixture is obtained, in the furnace, an extreme-

ly

ly black enamel, of the greateſt compactneſs, ſcattered over with white points, which are feltſpars not entirely vitrified. The magnetic needle is ſenſible to theſe ſhoerls at the diſtance of one line and four-fifths.

The ſecond product, which is from Monte Merlo, conſiſts of an aggregate of extremely white and ſhining half-cryſtallized feltſpars, of a changeable colour, which in the furnace produce a white, and ſpungy, but hard glaſs.

The third, which is from the ſame mountain, at firſt view, might be taken for a pumice, as it ſwims in water; but, when properly examined, appears to be a vitreous ſcoria, in the ſolid parts ſufficiently hard to give ſparks with ſteel; inflated and rendered ſpungy by the action of fire, and aëriform ſubſtances. The furnace perfectly vitrifies it.

Two other products, one from Maſcabo, near Praglia, the other from Tramonte, were

were true pitch-ſtone lavas, though Father Terzi believed them to be real glaſſes.

I had not time to certify myſelf with reſpect to the places where theſe productions were found; but I cannot doubt the truth of the accounts I received concerning them. I can at leaſt affirm, that there was no error with reſpect to the two products of which I ſhall now proceed to ſpeak, as I found them preciſely in the places which had been pointed out to me by the Reverend Father.

The firſt of theſe is met with at the foot of a very high rock, called Pendiſe, and forms a vein, which runs from eaſt to weſt, and, in the opinion of Father Terzi, is glaſs. Certainly, when we take off the outer coating, which, as in a great number of other ſtony ſubſtances, is in a ſtate of decompoſition, and, conſequently, has loſt, in a great degree, its external characters, the interior maſs may at firſt deceive the eye of the obſerver, and induce him to conſider it

as

as real glaſs. The aſpect is ſmooth and ſhining, like that of glaſs; but with ſome unctuoſity, as is the property of ſome leſs perfect volcanic glaſſes. But on examining, with greater attention, the pieces recently fractured, we do not find in them the characteriſtics of volcanic glaſs; as they have not the fineneſs of conſiſtence, the undulating ſuperficial ſtreaks, the ſharp edges, nor the acute points. We may even handle and preſs the flakes and fragments of them without fear, which cannot be done with impunity by volcanic glaſſes.

We know, likewiſe, that the primordial rocks, when they are changed by the action of ſubterranean fires into the nature of glaſs, are no longer recognizable; as they have loſt their primitive ſtructure, and are reduced, together with the extraneous ſubſtances they contain, as ſhoerls and feltſpars, to one ſimilar and homogeneous maſs; whereas, on the contrary, the vein in queſtion ſufficiently declares its origin, which is a petroſilex of a dark green colour, a fracture

ſomewhat

ſomewhat ſcaly and conchoidal, of a grain moderately fine, giving ſcarcely any ſparks with ſteel, and having, in the points, a very ſlight degree of tranſparency. The feltſpars and micas, however (of the former of which the number is but ſmall, but that of the latter very conſiderable), do not form one homogeneous paſte with the baſe, but are both in a ſtate of the greateſt preſervation. The feltſpars exhibit a cryſtallized form, but it is impoſſible to define it where the petroſilex has not been altered. It is not the ſame with the ſuperficial cruſt, the baſe of which, having been in part deſtroyed, holds theſe ſtones but feebly; ſo that they may eaſily be detached entire with a knife; when they appear to be priſmatic cryſtals, with tetrahedral rectangular facets. We cannot, therefore, in any manner, call this vein a glaſs, but only, at the utmoſt, a vitreous lava.

By the ſide of this volcanic rock, there is another, of a congenerous baſe, and containing the ſame micas and feltſpars; but it is of a pale green colour, and tolerably

 hard:

hard : it has not, however, the brilliancy of the former. Both theſe rocks produce in the furnace a greyiſh enamel, with an entire fuſion of the feltſpars, but not of the micas, which leave black points within the enamel.

The other product of which I went in ſearch, according to the directions given me by Father Terzi, was, in like manner, in his opinion, a volcanic glaſs, but detached and ſcattered. It is found near the Church of Valſanzibio. Having taken a ſpecimen of this into my hands, and examined it carefully on every ſide, I perceived that in this inſtance he was not miſtaken, and congratulated him and myſelf on the diſcovery. It exhibited, in fact, the moſt indubitable characters of a true glaſs. It was black, and gave ſparks with ſteel. I was, therefore, very anxious to examine the place where it was found, and repaired without delay to Valſanzibio ; where I found more than one piece of it, not infixed in the earth, nor in the midſt of any rock or ſtony vein, but looſe, and ſcattered over the ground, like

ſtones

ſtones in a public road. I was ſomewhat ſurpriſed at this; and, on making enquiries of ſome peaſants on the ſpot, they told me, that ſome ſhepherds had brought that glaſs from the grottos round the fountains of the garden of N. U. Barbarizo, at a little diſtance from the Church of Valſanzibio, and, finding it uſeleſs, had thrown it away there. I repaired, accordingly, to the place they pointed out, and found that it was, without the leaſt doubt, of the ſame kind. I, afterwards, learned from the keepers of the garden, that it had been procured from the ſcoriæ of the furnaces of Murano, near Venice.

I ſhall conclude this account of the volcanic ſpecimens of the Euganean mountains ſhown me by Father Terzi, in his cabinet of natural curioſities, with mentioning one more, which in his opinion was a volcanic glaſs, and had been found detached on Monte Merlo. To this, likewiſe, I cannot refuſe the appellation of glaſs. It is, like the former, black, compact, and heavy. As I did not go to the place where it was found, I cannot

cannot pronounce with certainty relative to its origin. It is poſſible that this glaſs may be the production of thoſe very ancient volcanos, ſince Sir John Strange, at number 62 of his Catalogue before cited, mentions ſome pieces of foſſil glaſs, but which are ſolitary and accidental, found in ſome parts of the Euganean mountains. It is not, however, abſolutely impoſſible but that it may be glaſs from the furnace; at leaſt the accident of the glaſs of Murano ought to teach us to be cautious, and ſuſpend our judgment relative to the queſtion, whether a mountain may have been volcanic or not, when we have no other proof than finding a looſe piece of glaſs, ſcoria, or other ſubſtance deriving its origin from fire, while we are uncertain whether that fire was, or was not, volcanic. For, even though the pieces found ſhould be really volcanic, they cannot afford a certain proof of the volcanization of the place where they are found detached. Of this I can produce an inſtance which happened to myſelf in a curſory viſit that I made to Capo Colonne, a promontory

of Attica diſtant twenty miles from Athens, when, in 1785, I accompanied his Excellency the Venetian Envoy, the Cavaliere Zulian, to Conſtantinople. I there found pumices ſcattered over the ground, to my no little ſurpriſe, as the place exhibited no indications of being volcanic. They were of that kind which, from their levity, ſwim in water; and, being of a globoſe figure, I ſuſpected that they had once flowed. On deſcending the promontory on the top of which theſe pumices are found, and proceeding to the ſhore, near a narrow peninſula, expoſed to the daſhing of the waves, I found three other ſimilar pumices, which authoriſed me to conclude that thoſe on the height above, which is about one hundred and ſixty feet above the level of the ſea, were ſome of thoſe that had been thrown by the waves on the ſhore, and afterwards carried thither by men: the only explanation of which, in my opinion, the caſe admitted. To the ſhore they had been brought by the ſea; for it is well known that many iſlands in the Archipelago are volcanic;

volcanic; and that Santorine, in particular, is only one immenſe mine of pumices *.

The objections which may be made to the relations that aſcribe a volcanic origin to a country, merely becauſe certain ſubſtances that bear the marks of ſubterranean fires are found in it, permit me to ſay, are equally applicable to other proofs of the ſame kind which are by no means more deciſive. Here, it is ſaid, there muſt have been a volcano, becauſe the matters found are extremely black, and therefore bear the characters of fire. There we are authoriſed to form the ſame opinion, becauſe lavas have iſſued from the entrails of a mountain, or volcanic veins and ſtrata are found in its fiſſures.

There are many writers who, without adding any other proof, uſe theſe expreſſions to ſignify to their readers the diſcovery of ſome ancient volcano. I do not

* See Chap. XIX.

deny the poſſibility of there having been a volcano in ſuch places; but I muſt affirm that theſe indications are equivocal, and, therefore, may be fallacious. It is true that many volcanic products are black, with a colour varying from the blackneſs of iron to a greyiſh black. It is equally true that, in a long ſeries of time, this colour is not loſt by many volcanic productions, as appears from ſome lavas in the Eolian iſles. But it is likewiſe true, that in many others the blackneſs diminiſhes in time, and, at length, totally diſappears, as we ſee in the greater part of the lavas of Veſuvius and Etna, which, though at firſt they approached more or leſs to a black colour, have gradually loſt that colour, till at laſt they have acquired one reſembling that of common earth. It is ſufficient merely to caſt the eye on the recent currents, thoſe of a moderate age, and the moſt ancient, of thoſe two volcanos, to perceive theſe ſucceſſive changes. Every lava, however, though of a recent date, is not black. The colour which is proper to the primordial

primordial rocks frequently does not diſappear in conſequence of the action of fire. The colour of many lavas approaches to a black, becauſe that was the colour of their reſpective primitive rocks, as we ſee in the lavas with a horn-ſtone baſe. In others it is a cinereous grey, and even white, becauſe they derive their origin from ſtones of a ſimilar colour, as, for inſtance, feltſpars and petroſilex. This diverſity of colours, black, grey, cinereous, and more or leſs white, is not unfrequently preſerved even in the enamels and glaſſes produced from theſe rocks when fuſed in the crucible. It is therefore certain that the colour of the products alone is not a certain indication of a volcano.

I conſider as illuſory, and not merely inconcluſive, the aſſerting the exiſtence of ancient volcanos becauſe there exiſt veins or volcanic matters; ſince this is the ſame thing as ſaying there are volcanos becauſe there are volcanos. And though a writer ſhould be convinced

from his own obſervation that theſe matters have really ſuffered the action of fire, if he wiſhes to convince the philoſophical world he muſt ſpecify their nature; as whether they are puzzolanas, aſhes, glaſſes, enamels, ſcoriæ or lavas. The preciſion and exactneſs required in the preſent diſcerning age likewiſe render it neceſſary that he ſhould characterize theſe different volcanized ſubſtances; and it will be to little purpoſe that he adduces in proof of an extinguiſhed volcano the remains of a current of lava, unleſs he properly deſcribes it, ſince the advancement of this ſcience depends entirely on exact deſcriptions of products affected by the fire. The moſt able volcaniſts of the preſent time write after the manner of accurate mineralogiſts. Among theſe volcaniſts, the firſt place is certainly due to M. Faujas de Saint Fond, as is ſufficiently proved by his *Mineralogy of Volcanos*.

And here I cannot refrain from making ſome obſervations relative to lavas in general.

ral. By the word lava is underſtood, as every one knows, a liqueſied ſtony ſubſtance which has been in motion. When a mountain is of a conical form, and has a cavity reſembling an inverted tunnel on its top, or evident marks of one, and when from this tunnel, as from a central point, a number of ſtony ſtrata diverge towards the lower parts with a waving form, or with inequalities and tumours, we cannot doubt the preſence of lavas. It is equally indubitable, when we are certain of the volcanization of the mountain from other ſigns, and ſee theſe ſtony ſtrata ariſing from its ſummit, and tending downwards, with the wavy appearance and inequalities before mentioned, though there ſhould be no apparent indication of a crater. When we aſcend to the ſummit of thoſe Eolian Iſles in which the remains of craters are no longer viſible, we immediately diſcover conſpicuous currents of lava. There may, however, be caſes, with reſpect to mountains that have ſuffered the action of fire, in which, from want of local circumſtances,

we may remain in doubt whether the volcanized rocks that preſent themſelves to our view, have ever actually flowed. This doubt I experienced myſelf, when I firſt viſited the Euganean mountains, in conſequence of my obſervations relative to the primitive rocks, and the experiments I had made on lavas in the furnace. I conſidered that it was poſſible the rocks of the Euganean hills might never have flowed in currents, and conſequently that they could not have been lavas, though they might bear very ſenſible marks of fire, and even the ſame with vitreous lavas; as I was convinced from the experiments I had made in the furnace, which, without wandering too far from my ſubject, I will here briefly deſcribe.

In Chap. XI, I have ſpoken of the fuſion of ſome porphyries with a horn-ſtone and petroſiliceous baſe. The following are the appearances I obſerved ſome time before their fuſion. The pieces, though before their fractures were ſcabrous and angular, aſſumed

aſſumed a ſmooth and vitreous ſurface. Their internal grain acquired an aſpect rather vitreous than ſiliceous, even in thoſe ſtones, which, having for their baſe the horn-ſtone, had an earthy appearance. The pieces, except that they adhered by ſome points, preſerved their former figure and angles; which preſervation of the figure takes place in other caſes that I ſhall proceed to mention.

The feltſpar of Mount St. Gothard, or the adularia of Father Pini, loſt its changeable colour and tranſparency, became white within, ſemi-enamellar, and vitreous externally.

In the feltſpars of Iſchia, the vitrification penetrated to the depth of ſome lines.

In ſome of the potteries of Pavia, they uſe a kind of earth, which, from the place where it is digged, is called *biella*, which ſtrongly reſiſts the fire. It is commonly found

found to be compoſed of alumine, ſilex, and a very ſmall quantity of lime. It is uſually refractory to the fire of a glaſs furnace; but ſometimes will fuſe when it contains a rather larger proportion of lime. Of this kind of earth I made ſome ſmall ſpheres and cubes, which I left four or five hours in the furnace; when the vitrification had penetrated to the depth of two thirds of a line, and in ſome even a whole line, and the central part had become ſemivitreous.

Similar effects take place in lavas. Their ſurface aſſumes an enamel or vitreous aſpect, which in the internal part is leſs apparent. In ſome, however, we find points which have become vitreous, though theſe lavas before did not contain a ſingle atom of glaſs. In general, they loſe that grain and texture, which indicate the primitive rocks whence they were derived, and they all, or nearly all, may be called vitreous.

Thus

Thus we have a prodigious number of foſſil productions which have the moſt ſpecious appearances of lavas, and vitreous lavas, though they have never ſuffered liquefaction; as is incontrovertibly proved by the pieces, which, when they come out of the furnace, retain exactly the configuration they had before they were expoſed to the fire.

Inſtructed by theſe facts, I confeſs that the firſt time I ſaw the Euganean mountains, and found myſelf in a theatre very different from that preſented by the Eolian iſles, not to mention Etna and Veſuvius, I could not avoid entertaining doubts whether the numerous rocks, which in a great part form theſe mountains, owed their origin to volcanic eruptions, or were pre-exiſtent to the ſubterranean conflagrations, that had only penetrated them, infixing in them indelible traces of their action, but ſtill leaving them in the place where we at preſent ſee them. Every doubt however was removed, and I remained convinced that

theſe

theſe prodigious maſſes of rocks were igneous eruptions, or, in fact, currents of lava, of which the poroſity of ſome of them was a very evident and ſatisfactory proof. It is indubitable that the elaſtic gaſes, which generate pores and vacuities in the rocks acted on by fire, cannot produce that effect unleſs theſe rocks are ſoftened ſufficiently to yield to the expanſive force of theſe aëriform ſubſtances, which muſt preciſely happen in their actual liquefaction. This, though ſufficiently evident in itſelf, is undeniably proved by experiments I made in the furnace. When the porphyries with a petroſiliceous or hornſtone baſe, and, generally, when compact lavas aſſumed the ſimple vitreous varniſh, and ſomewhat of a vitreous aſpect internally, but without the pieces conglutinating and forming one ſingle uniform maſs, they rarely or never contained bubbles; which, on the contrary, were conſpicuous and numerous when the fuſion was complete, and the larger, the greater the degree of liquidity produced by the fire in the ſtony bodies.

The

The porosity of volcanic rocks is, therefore, a decisive proof that they were once in a fluid state. Several of the Euganean rocks are porous and cellular, as I have already shown of more than one, and shall proceed to show of some others.

There is a declivity on one of the Euganean mountains, the name of which I cannot give, having neglected to note it in my journal, an omission of little importance to the truth of the fact; which declivity is composed of a rock with a horn-stone base, containing feltspathose crystals, and full, both on the surface and in the internal parts, of round vacuities, such, precisely, as are usually produced in lavas by aëriform fluids.

I shall make a few more observations on the Euganean lavas; and shall notice that one of them containing bubbles, and that in a considerable number, is found in immense quantities in, and on the side of, the road leading from Bajamonte to Rua.

This lava, which has for its baſe the horn-ſtone, and emits a ſtrong argillaceous odour, has the colour of a dead leaf, a grain ſomewhat ſandy, and a great number of round pores, from thoſe of a ſize ſcarcely diſcernible, to others ſeven lines in diameter. Many of theſe pores are occupied by cryſtallized globules of carbonate of lime, produced by filtration. This lava has the external appearance of being very ancient. In the furnace it affords one of the uſual black and opake enamels.

To the ſouth-weſt of a declivity of Rua we find great maſſes of a volcanic rock that has fallen down, the feltſpars of which are an exception to thoſe of the innumerable lavas deſcribed in this work on account of the extraneous bodies encloſed within them. This rock, the different pieces of which are of different colours (ſome being aſh-grey, others red, others of a pale violet), is of a petroſiliceous baſe, with an earthy grain, and contains, beſides hexagonal micas with oblique ſides, tranſparent feltſpars, cubical, priſmatical,

priſmatical, and ſometimes amorphous, which give ſparks ſtrongly with ſteel, and form very brilliant plates. The largeſt are five lines and three quarters in length. Each of theſe feltſpars includes within it a ſmall portion of the petroſiliceous baſe, which forms in it a kind of nucleus, and occupies a conſiderable part of its ſubſtance. But to what cauſe are we to aſcribe this ſingularity? I can conceive no other method of explaining it, but by ſuppoſing, that when the integrant particles of the feltſpars, diſſeminated in the earthy and liquid baſe, united by the force of aggregation in cryſtallized maſſes, each of theſe maſſes included a ſmall part of this baſe, greater or leſs in quantity. The rarity of the phenomenon, however, ſuppoſes a local circumſtance, which had a direct relation to this ſingular combination, and of the nature of which I am ignorant.

The feltſpars fuſe in the furnace, and become intimately mixed with the baſe in ſuch a manner, that the reſult is a ſolid, white, ſemi-tranſparent glaſs, with black ſpots, occaſioned

ſioned by the micas of that colour which have remained, in a great meaſure, refractory.

I ſhall omit to deſcribe another porous lava, likewiſe from Rua; and two of the compact ſpecies, with a horn-ſtone baſe, found in that vicinity. I think more deſerving of attention one diſpoſed in ſtrata oblique to the horizon, which is found on the ſides of the road leading from Galzignano to Cieſa.

This lava is white, and has the compactneſs of fine carbonates of lime, which it reſembles in appearance, fracture, and weight. It affords a few ſparks with ſteel, and is diſtinguiſhed from other lavas by numerous points of a delicate green, ſcattered over the white ground; but which, to be viewed diſtinctly, require a lens with a ſtrong light. When thus magnified, we find that they are a ſemi-pulverous earth, which may be detached with the point of a needle, and is placed between the fiſſures of minute amorphous maſſes of ſhining, white, and extremely

tremely tranſparent quartz. I know not whether this powder be a decompoſition of quartz, which, however, does not appear very probable, as it is found deep in the internal part of the lava, where it is not in the leaſt altered; or whether it be an extraneous and adventitious ſubſtance. Beſides the quartzoſe grains, the petroſiliceous baſe contains a few very ſmall feltſpars, which, from their changeable brilliancy, their rhomboidal form, and their being compoſed of minute laminæ, cannot be confounded with the quartzoſe grains.

It is neceſſary to obſerve that the baſis of this lava, in the furnace, ſerves for a flux to theſe quartzoſe grains; the reſult being a homogeneous and white enamel, without the ſmalleſt appearance of any remains of the quartzoſe grains, or the feltſpars.

Another lava, found on each ſide of the road, in a place called the Pigozzo, oppoſite

Catajo, is in no reſpect different from this, except that the quartzoſe grains are not accompanied with green ſpots. It yields in the furnace the ſame volcanic product.

At Monte Nuovo we find ſeveral maſſes of a lava which deſerves our notice, from its being reduced to ſuch a ſtate that it is pulverable by the mere preſſure of the finger. It has an argillaceous baſe, and contains an abundance of feltſpars which have preſerved their priſmatic figure, but are nevertheleſs pulverable. It is rare, in volcanic places, to find feltſpars ſo much injured, even where they have been acted on by ſulphureous acids; of which there are here no traces: and therefore this decompoſition ſeems to be derivable from the humid elements, and other cauſes in the atmoſphere. On breaking this lava we diſcover ſome minute octagonal and hexagonal priſms, obliquely truncated, leſs ſoft than the baſe to which they are attached. They do not in the leaſt appertain to the genus of either

ſhoerls

ſhoerls or feltſpars; and, in their external characters, ſeem not to differ eſſentially from the lava itſelf.

Among the number of the pitch-ſtone lavas already mentioned there is one which muſt peculiarly attract the attention of volcaniſts, from the pumices it contains. Monſelice, one of the Euganean mountains, which ſtands detached, and is of a moderate extent and height, is partly compoſed of a white argillaceous lava, of an earthy aſpect, in which we find this peculiarity; only that, while the pumices of the pitch-ſtone lava are derived from the parts of it being dilated and tumefied by gaſeous elaſtic ſubſtances, thoſe of the preſent lava appear to be adventitious, conſiſting in white globules eaſily ſeparable from the baſe, from which probably they were taken when it was in a fluid ſtate. Except that they are leſs, they conſiderably reſemble the pumiceous globules of Pompeii near Veſuvius; and both, in the furnace, produce a ſimilar enamel.

This lava, beſides the pumices, contains elegant feltſpathoſe cryſtals, which, together with it, completely vitrify in the furnace.

Monte d'Arqua was the laſt which I viſited. Its ſummit is compoſed of a grey compact lava, which has a horn-ſtone baſe, affords ſparks with ſteel, and contains micaceous and feltſpathoſe cryſtals. This lava is found in ſome places in ſtrata nearly horizontal.

To theſe lavas, which I found on the ſpot, while accompanied in my reſearches by the Marcheſe Orologio, I ſhall add a few others from the Monte del Catajo, which were afterwards noticed and examined by that illuſtrious nobleman and naturaliſt, who viſited every part of that mountain to which his villa is contiguous, and collected ſpecimens of the ſpecies of moſt importance, obſerving the places where they were found. At my requeſt he tranſmitted them to me, with their ſeveral

veral deſcriptions, which I ſhall here briefly give the reader, only making ſuch alterations as appear to be neceſſary.

I. Is one of the fineſt lavas of the Euganean mountains. Its baſe is feltſpar in the maſs, but it is with difficulty recognized from its exterior characters, the fire having changed it into a vitreous lava. It is of a cinereous colour, compact, but not very hard, on account of its numerous fiſſures. It contains cryſtallized micas and feltſpars; and the enamel it produces in the furnace, ſimilar to that of the pitch-ſtone lavas, forms one homogeneous maſs with the fuſed micas and feltſpars.

This lava, on which the noble palace of the Marcheſe degli Obizzi is built, occupies an extenſive tract of the ſides of Catajo, to the ſouth; and branches off, likewiſe, to the north-eaſt; though, from its being there in a ſtate of the greateſt decompoſition, it has loſt the characters of a vitreous lava, and taken thoſe of an earthy and

pulverulent. The experienced, however, may ſtill diſcern within it the vitreous lineaments ; and I am convinced that, were a deep excavation to be made in this lava, we ſhould more completely diſcover its vitreous nature ; as, by the ſame means, we aſcertain the real quality of other ſtones, both natural and volcanized, the ſurface of which has been changed by the action of corroſive agents.

In the internal part of this decompoſed lava, we find ſeveral globes of petroſilex as ſtrongly characterized as in the natural ſtate. As it is detached, I dare not number it among the lavas. Similar to many congenerous ſtones, it is ſurrounded with a white argillaceous cruſt, which attaches to the tongue ; and contains a number of micaceous points, and feltſpathoſe laminæ.

In the furnace it becomes white, and acquires a thin vitreous coating : the pieces, however, do not loſe their primitive figure.

II. This

II. This lava is found at about one quarter of the aſcent up the mountain, and continues to the top: it is alſo met with in detached pieces along the declivities. The baſe of this lava is a compact, heavy trapp, of very fine particles, interrupted with feltſpathoſe ſcales. It has the black colour of iron. The furnace changes it into an enamel full of bubbles; but it retains its former colour.

III. This ſpecies is in part buried within the lava No. II; and, in part, iſſues from it, forming tortuous veins of various ſizes, and running in various directions, one of which interſects the decompoſed vitreous lava No. III. The baſe of this lava is an extremely compact petroſilex; it is of a greyiſh blue colour, inclining to a black. Its fuſion in the furnace was complete at the end of thirty-eight hours.

IV. This lava is white, light, and de-

compoſed in the ſame manner as ſome tracts of that of No. I. Its baſe is argillaceous, and it attaches to the tongue; the ſmall cryſtals of black mica and feltſpar which it contains, are, however, uninjured. This lava, likewiſe, iſſues in veins from the body of that of No. II.

Its product in the furnace is a ſemi-tranſparent grey glaſs, with the fuſion of the feltſpars. This lava has the peculiarity of ſtrongly attacking the crucible; combining with the earth of which, it forms round the ſides an elegant, extremely tranſparent glaſs, reſembling the emerald.

V. Beſides ſeveral beds of pitch-ſtone lava, which concur to the formation of Catajo, there is one, near the ſummit, towards the ſouth-weſt, interſperſed with innumerable very fine white ſtreaks parallel to each other, and which form a ſtrong contraſt to the red ſtreaks of the pitch-ſtone lava. Theſe white ſtreaks, as far as I could diſcover, are the ſame lava decompoſed,

and perhaps rendered ſuch by the filtration of the rains which have inſinuated through the ſmall fiſſures of the lava.

In the furnace it changes into an enamel ſimilar to that afforded by the other pitch-ſtone lavas, with the liquefaction of the felt-ſpars it contains.

VI. This lava is thus deſcribed by the Marcheſe Orologio:

" Near the top of the firſt ſummit" (the Monte del Catajo is bifurcated) " there is a " ſpacious irregular plain with many in- " equalities, which I incline to ſuſpect was " an ancient crater deſtroyed by time, and " filled by the falling in of its ſides. We " here find enormous maſſes of a ſpecies of " breccia, or pudding-ſtone, compoſed of " ſmall fragments of many varieties of lava, " united and bound together in a hardened " clay."

This breccia I carefully examined, and conſider

conſider it as well deſerving attention. Black ſhoerl in the maſs conſtitutes the greateſt part of it. It is found in pieces ſurrounded by a grey earthy cruſt, which attaches to the tongue, and is a decompoſition of the ſhoerl. The cruſt in ſome pieces is extremely thin, but in others extends to a greater or leſs depth; and in ſome leaves only a black ſhoerlaceous point in the middle. Theſe ſmall pieces are uſually angular; whence we may infer that they have not been in a fluid ſtate. They are all bound together by a cement, ſmall in quantity, of a pale yellow colour, and a vitreous aſpect, which is likewiſe changed by the decompoſition. The breccia in the furnace is reduced to a black and frothy ſcoria.

The decompoſition of this breccia appears to be a conſequence of the action of the atmoſphere and of time. The ſhoerlaceous fragments evidently ſhew that they exiſted previouſly to the vitreous ſubſtance; which paſſing over them when it was in a fluid ſtate, included them within it, and formed

one

one body with them. They may, alſo, poſſibly be ſmall fragments of a very ancient lava, with a baſe of ſhoerl in the maſs; unleſs we rather chooſe to ſuppoſe that ſome vein of ſhoerl, broken by the impetuoſity of the elaſtic gaſes, and reduced to minute pieces by the ſhock, has been thrown out from a volcanic mouth, without having been fuſed or changed by the fire.

VII and laſt Lava. Though this be ſpecifically the ſame with No. II, it claims to be diſtinctly mentioned from the manner of its conformation. About half way up one of the ſummits of the mountain, there is an overhanging precipice, from which go off two ranges of priſmatic columns; the one higher than the other, but both nearly vertical. Their height differs from thoſe of one foot to thoſe of three. When we conſider the precipice, or rent in the mountain to which they adhere, and the circumference of it, we perceive, that, when it was entire, they extended to but a little diſtance from their central point. The baſe of this column

is a trapp, which, in reſpect to its conſiſtence, and the feltſpars it contains, extremely reſembles that of No. II.

This ſtone puts in motion the magnetic needle at the diſtance of ſcarcely two lines; and may ſerve for a touchſtone; a quality remarked by Cronſtedt in the Swediſh trapps.

REFLEC-

REFLECTIONS AND COROLLARIES.

THE facts explained in the preſent chapter are highly inſtructive, from their teaching us the nature of the different volcanic rocks of the Euganean mountains; but they are ſtill much more ſo from their enabling us to form a compariſon between theſe volcanos and others in Italy and its vicinity, either extinguiſhed or at preſent burning. We are taught by obſervation and experience, that nothing exiſts in nature detached and ſolitary; but that the whole is connected with a variety of relations, and that we can acquire an accurate knowledge of no ſingle part but by means of compariſon. In my other works on phyſical ſubjects, I have conſtantly made it the primary object of my ſtudies and reſearches to analyſe and compare the facts I diſcovered with each other, and with ſimilar facts diſcovered by other

other authors; and in the preſent work I certainly ſhall not depart from a method which appears to me beſt adapted to enlarge the limits of our knowledge of nature, and increaſe the treaſure of uſeful ſcience. With this view, therefore, I ſhall add the following brief reflections:

Though the ſea is now ſome miles diſtant from the mountains of Padua, it is beyond all doubt that it anciently waſhed them; as is proved by the calcareous carbonates, and their horizontal ſtratifications, beſides the marine ſhells found on them, and mentioned by many authors. It ſeems equally indubitable, from the obſervations of Sir J Strange and the Abbé Fortis *, that this group of low mountains and hills was once ſo many volcanic iſlands, reſembling thoſe of Lipari, Ponza, Santorine, and innumerable others of the ſame

* Memoria Geografico-Fiſica intorno la vera ſituazione dell' Iſole Elettridi degli Antichi——A Memoir relative to the true ſituation of the Iſles Electrides of the Ancients.

kind;

kind; except that in the very ancient volcanos of Padua any perceptible ignition has gradually diminiſhed and diſappeared, nothing remaining but ſome feeble reſidue in the well-known warm baths. This antiquity, it cannot be doubted, likewiſe, is the reaſon why theſe mountains, notwithſtanding they ſtill retain the figure which characterizes them as volcanic, are greatly changed in their external appearance, being deprived of their craters, probably by the falling in of their ſides and the effects of rains; as alſo their porous and ſcoriaceous lavas having been reduced to cultivable earth by the induſtry of men. The vicinity of theſe places to others that have long been cultivated, may likewiſe have greatly contributed to diminiſh their original wild aſpect, and render them very different, in conſequence of cultivation, from other mountains which, though they have long ceaſed to burn, have been deſtitute of population.

It may here be proper to conſider how great

great an analogy the lavas of the Euganean hills have with thoſe ejected by other volcanos more known to be ſuch, as theſe are not ſimple ſtones, but compound; I mean what are called rocks. The lavas of Etna, which uſually have for their baſe the horn-ſtone or ſhoerl in the maſs, contain feltſpars, cryſtallized ſhoerls, or chryſolites. Feltſpars, garnets, and cryſtallized ſhoerls are incorporated in the lavas of the volcanos of the Eolian iſles, in a baſe of petroſilex, horn-ſtone, and ſhoerl in the maſs. Petroſilex, horn-ſtone, and garnets are conſtantly accompanied by ſhoerls, feltſpars, and micas in the lavas of Veſuvius *. Thoſe of Iſchia with a horn-ſtone baſe abound in feltſpars †. The iſlands of Ponza afford both granitous and ſiliceous lavas, accompanied with ſhoerls, feltſpars, and micas; and St. Fiora in Tuſcany is compoſed of granitous lavas ‡.

* Gioeni, ubi ſup.

† See Chap. V.

‡ Dolomieu, ubi ſup.

The

The products of the Euganean mountains, we have seen, are perfectly similar. The base of their lavas, which is shoerl, feltspar in the mass, pitch-stone, horn-stone, or petrosilex, is combined with feltspar, crystallized shoerl, or quartzose grains. And though I only examined a part of these mountains, yet, from the more extensive observations of Sir J. Strange, we are authorised to say that the nucleus of them all is composed of this stone. It is therefore evident that the ancient subterranean fires, which have laid waste a great part of Italy and the adjacent countries, have had their seat in these rocks; and who can say to how immense a depth they may have extended beneath the surface of the earth? I say beneath the surface, because, though by the violence of volcanic fires large and numerous masses arise above the surface, both on this and the other side of the Apennines, they never, or scarcely ever, concur to the formation of these, which principally result, as may be observed in many parts of them, from the calcareous

carbonates, ſteatites, arenacious ſtones, and of a ſpecies of quartzoſe, micaceous, ſchiſtus, on which, in a great meaſure, they reſt. It is not, however, improbable that this order of rocks, unaffected by the fire, lies buried under the great body of the Apennines.

I made no excurſions to the Vicentine mountains, which we know to be at once of a volcanic and marine origin. We have, likewiſe, no accurate lithology of that intereſting country. But from ſome ſpecimens which I received from ſome friends, and, among others, from Signor Giovanni Arduino, and eſpecially from the converſations I had with him on the ſubject at Venice; I clearly underſtand that the lavas found there have rock for their baſe; which rock is ſometimes a petroſilex, and ſometimes a horn-ſtone; the extraneous bodies contained within them are ſhoerls, feltſpars, and micas. Sometimes the volcanic rock is granitous.

I ſhould

I ſhould wander beyond the limits I have propoſed to myſelf, ſhould I proceed to conſider the nature of the ſtony ſubſtances which have been acted on by volcanic fires out of Italy, and have been deſcribed by naturaliſts of experience and worthy of credit. I ſhall only ſay that theſe deſcriptions are ſufficient to ſhow that they are all, or almoſt all, rocks or compound ſtones. As therefore the fires of volcanos extend to a prodigious depth, as may be deduced from the vaſt mountains they raiſe above the earth; it follows that theſe rocks, beſides conſtituting numerous chains of very lofty mountains, deſcend to an immenſe depth, even in thoſe places where we ſhould not know that they exiſted, were they not diſcovered by fiery eruptions. We thus perceive how extenſively thoſe rocks contribute to form the rind, or ſuperficial coating, of this globe; the only part of it which man is permitted to examine; and which we never could have obtained knowledge

of to ſo great a depth, but for the fiery torrents that have iſſued from it.

Three different baſes of the Euganean lavas have engaged my attention; the feltſpar in the maſs, the petroſilex, and the pitch-ſtone. The former of theſe is changed by the action of the fire into a vitreous lava, the equal to which I have not ſeen among the products of any other volcanos that I have examined. It has been already obſerved, that in the Eolian iſles the feltſpar in the maſs has contributed to the formation of many lavas; but theſe cannot claim the name of vitreous, as they retain more or leſs of the external appearance of the feltſpar; or this feltſpar has paſſed immediately into glaſs or enamel.

The petroſilex, likewiſe, forms a kind of general exception with reſpect to the Eolian volcanos. We have ſeen that many of their lavas have the petroſilex for

for their baſe. This ſtone almoſt always ſufficiently preſerves in them its primitive characters; but it is accompanied with a principle, if I may uſe the expreſſion, of fibroſity and expanſion in its parts, which exhibits no obſcure ſign of its having been acted on by the fire. The lava with a petroſiliceous baſe, of the crater of Vulcano *, is the only exception. On the contrary, ſeveral of the Euganean petroſilices, with reſpect to their texture, grain, compactneſs, and fracture, ſo exactly reſemble the moſt perfectly characterized natural petroſilices, that they might be miſtaken for them, if we did not find that they have paſſed into the ſtate of lava. This peculiarity, however, is not confined to the Euganean volcanos; it likewiſe appertains to thoſe of the iſles of Ponza, as has been ſhown by M. Dolomieu in great numbers of lavas with a petroſiliceous baſe. Theſe lavas cannot but greatly excite our admiration, as we find it impoſſible to conceive,

* See Chap. XIII.

from the knowledge we have of our common fire, how such a stone can be liquefied and flow without losing one of its natural lineaments.

Lastly, the lavas with a pitch-stone base, which are very abundant in these mountains, are a third object deserving our attention. It is not certain that Etna or Vesuvius have ever thrown out a single fragment of them: and the same observation may be made of the rest of the Phlegræan fields. In Lipari alone, among all the Eolian islands, I have found detached and scattered pieces, but which had rather passed into the state of enamel *. The volcanic pitch-stone is not peculiar to the Euganean mountains: the volcanos of Hungary and those of Auvergne furnish some noble specimens of it. It remains, however, to enquire whether it is to be classed among the lavas, or rather whether it has ever formed currents. We may be

* See Chap. XVII.

satisfied

ſatisfied that it muſt, as well as the pitch-ſtones of the iſles of Ponza, from the obſervations of Dolomieu. According to this author, the ſimilar kinds of lavas found in theſe two countries have for their baſe the feltſpar, with a very conſiderable quantity of magneſia * ; and, in a note to his work on the iſlands of Ponza, ſpeaking of the Vicentine lavas, he remarks, that he found among them ſome productions of pitch-ſtone, which he could not conſider as a true volcanic product, but rather as a concretion formed afterwards by the decompoſition of volcanic matters ; and that they contained a great quantity of magneſia. From which we may gather that magneſia, in the opinion of this author, is one of the conſtituent principles of the pitch-ſtones of volcanos. The truth however is, that in the three analyſes above mentioned, of the pitch-ſtone lavas of the mountains of Sieva and Bajamonte, two of the Euganean mountains, I did not find an atom of this earth.

* Notes on Bergmann.

The Abbé Fortis affirms that he had diſcovered, in the pitch-ſtone lavas of Monte Brecalon, the evident tranſition of petroſilex into pitch-ſtone lava; and on comparing the analyſes of petroſilex made by others, with thoſe I have made of three pitch-ſtones, it will be found that they perfectly agree—with no other difference deſerving notice, but that the petroſilex uſually contains no iron, of which a very ſmall quantity was found in the pitch-ſtones I analyſed.

As it has been already ſhown, that pitch-ſtones that are not volcanic and thoſe which are, are of the ſame genus, I find little difficulty in believing that many of the latter are derived from the former.

In all my reſearches relative to the rocks of the volcanos in the two Sicilies, I have always been attentive to diſcover at what degree of heat they fuſe in our common fire, that I might infer the activity of the

ſubterranean

ſubterranean conflagrations by which they have been melted. I have proceeded in the ſame manner with reſpect to the volcanic rocks of the Euganean mountains, employing conſtantly the ſame fire, I mean that of the glaſs-furnace. As to the baſes of theſe rocks, we have already ſeen that not one of them proved refractory, not even excepting the hardeſt and moſt compact petroſilices, which have formed currents. The feltſpars and micas, with which the Euganean lavas ſo abound, appeared equally fuſible.

The eaſy fuſibility of the feltſpars excited in me ſome ſurpriſe, when I conſidered the infuſibility which, if not conſtantly, is very frequently the property of the ſame ſtones in the rocks of other volcanos when expoſed to the ſame degree of heat; and, as I obtained the ſame fuſion when the Euganean feltſpars were detached from their baſe, it cannot be alleged that this baſe ſerved as a flux. A difference ſo remarkable, it ſeems probable, can only proceed from the different proportions

of the conſtituent principles, unleſs we chooſe to ſuppoſe that in the Euganean felt-ſpars, beſides the elements common to that ſtone, there exiſts ſome other which facilitates their fuſion, though it is imperceptible to the eye, the external appearance of the fuſible exactly reſembling that of the infuſible feltſpars.

With reſpect to the product by fuſion in common fire, of the lavas of the Euganean mountains, it is found to be exactly the ſame with that of other lavas, I mean an enamel or glaſs, as appears from what has been ſaid above. The action of our common fire, therefore, deſtroys in theſe volcanic products that primitive characteriſtic ſtructure which had been left in them by the ſubterranean conflagrations.

The baſaltes of Vulcano and Felicuda are products of fire, and equally ſo are thoſe of Monte Roſſo, Monte Ortone, and Catajo; for they are integrant parts of continued volcanic rocks; which truth did not eſcape the

the acute obſervation of Sir J. Strange and other diſcerning naturaliſts. It deſerves remark, likewiſe, that the trapp has taken a priſmatic configuration at Catajo, in the dry way, and in Sweden in the humid, as has been elſewhere ſhown. This may teach us, that we can only determine by local circumſtances in which of the two ways baſaltes have been formed.

Theſe two ways, however, have united in the formation of the hills and mountains of Padua, as appears from the mixture of calcareous carbonates with lavas. This combination, which is not found in the Eolian iſles, but is obſervable in the Vicentine mountains, at Veſuvius, in the extinguiſhed volcanos of the Val di Noto in Sicily, in thoſe of Portugal, and Germany near Old-Briſach, and probably in other volcanized mountains, ſhould incite the naturaliſt to enquire which of theſe two contrary agents was prior in point of time. I ſhall not enter into this queſtion, which indeed appears to be precluded by the obſervations of the

Abbé

Abbé Fortis; my only object, in fact, being, in this ſhort excurſion to the Euganean mountains, to collect ſome of their volcanic products in the places where they are found, without entering into a very minute examination of the nature of thoſe places, and faithfully to give ſuch a deſcription of them as might contribute to enlarge our knowledge relative to volcanos.

CHAP.

CHAP. XXI.

EXPERIMENTAL ENQUIRIES RELATIVE TO THE NATURE OF THE GASES OF VOLCANOS, AND THE CAUSES OF THEIR ERUPTIONS.

The perfect reſemblance of the effects produced by ſome gaſes of volcanos and thoſe of others generated in lavas, and other ſimilar ſubſtances, when re-melted in our common fire, may enable us to diſcover the nature of the former, by inveſtigating that of the latter—Matraſſes of clay, filled to a certain height with volcanic products, expoſed to the fire of a chemical furnace, and communicating with a pneumatic-chemical apparatus prepared with mercury—Experiments made in this manner on the ſpotted glaſs of Lipari—Phenomena obſerved within the matraſs during ignition—No gas appeared above the mercury—Ebullient ſtate in which the glaſs was found when

when left to cool in the matraſs, after having been eight hours expoſed to the fire—No reaſon to believe that the bubbles were an effect either of the atmoſpheric air included in the interſtices of the glaſs, or of any permanent gas—Conjecture that theſe bubbles proceeded from the gaſification of the glaſs itſelf, occaſioned by the vehemence of the heat—Proof of this conjecture in the pureſt glaſs of Lipari—The breaking of the matraſs in the ſtrongeſt heat occaſioned by this gaſification—Cauſe why the glaſs rendered gaſeous does not paſs into the pneumatic apparatus—Breaking of a third matraſs by the violent gaſification of an enamel of Iſchia—Enamel of Procida during the gaſification ſublimed, and adhered to the ſides of the matraſs in the form of a thin cruſt, and enamel points—Confirmation of this in another matraſs, uſing the ſame enamel—Evident ſigns of this ſublimation in the fuſion of ſome volcanic ſubſtances placed in the furnace in covered crucibles—Reaſon why this ſublimation does not appear in every experiment—Black factitious

tious glaſs which does not produce gas in the furnace, but which produces it, within matraſſes, in a ſtrong heat—Experiments on ſix other volcanic bodies, which produce little or no gas in the furnace, but a conſiderable quantity in matraſſes, without any appearance of permanent gas—Concluſion that the bubbles and inflations of various ſizes, which we ſo frequently obſerve in the productions of volcanos, are not the effect of any permanent gas which has acted on them, but of an aëriform fluid proceeding from the exceſſive ſubtilization of thoſe productions by means of heat—Not but that volcanic products, expoſed to our common fire, ſometimes emit permanent gas—Proofs, deduced from facts on a ſmaller ſcale, that this aëriform fluid, in the deep receſſes of a volcanic crater, being abundantly mixed with the liquid lava, and ſtrongly excited by the ſubterranean conflagrations, may, by its violent force, raiſe the lava to the ſummit of the crater, and compel it to flow over the ſides and form currents—Another proof of this fact, which

which renders probable the hypotheſis, that this elaſtic vapour, collected in a large quantity, and finding ſome impenetrable obſtacle under the earth, may cauſe earthquakes, ſubterraneous roarings, and burſt the ſides of the mountains, forcing the lava to flow out—Improbable, however, that this vapour is the cauſe of the fiery hail ejected by volcanos—Neceſſity of recurring to other more powerful gaſes to explain theſe eruptions—The preſence of theſe different gaſes clearly indicated in ſome volcanos—Probable, that in the greater and more terrible ejections another agent much more energetic concurs, that is, water, principally that of the ſea, reduced to vapour—Connection between burning volcanos and the ſea—The ſudden retiring of the latter, in the vicinity of Veſuvius, at the time of the moſt terrible eruptions, probably occaſioned by great quantities of its waters being abſorbed in the caverns of the mountain—Experiments and accidents which prove the terrible nature of the exploſions and detonations of volcanos, in conſequence

of

of waters being reduced to vapour by their conflagration—Enquiry whether water falling upon a burning volcano may be capable to produce explosions, as it is certain it will if it insinuates itself in from below, and its vapours cannot otherwise obtain a passage out—Water falling upon oily and boiling matters generates feeble explosions, which seems to favour the affirmative—Arguments for the negative deduced from the effects of water poured on some melted substances, which are more analogous than oily to the liquefied matters of volcanos—No explosion or detonation occasioned by water falling on crystal liquefied in the furnace—Curious phenomena observed in this experiment—Similar effects produced by letting fall the same fluid on iron or copper in a state of fusion—Explosions and detonations in water, as soon as it touches the surface of melted tin or lead—These explosions greater when the water remains enclosed within these melted metals—Remarkable diversities in these experiments—Experiments on lavas melted in the

furnace—No explosion produced by pouring water on them, when it is not introduced within them—The explosion the stronger the more the water penetrates into them—The results the same when sea-water is used instead of fresh—Conclusion, that water is incapable of producing ejections when it falls on the burning craters of volcanos; but that it must produce very violent ones when it penetrates into them from below or by the sides—The different permanent gases discoverable in volcanos seem alone to be the cause of the more moderate and smaller eruptions—The symptoms, and incessant ejections, of Stromboli cannot be caused by the evaporation of water, nor by that of the liquefied lava, but must depend on the activity of some permanent gases—Enquiry whether this gas be hydrogenous—That supposition rejected—It cannot be supposed to be atmospheric air—The hypothesis which has recourse to oxygenous gas to explain the phenomena of the volcano of Stromboli, seems least improbable.

HAVING

HAVING finiſhed the deſcription of the products I obſerved in my excurſion to the Euganean mountains, I might conſider my volcanic travels as concluded; but agreeably to the plan I propoſed to myſelf in the Introduction to this work, it ſtill remains for me to diſcuſs ſome particulars which have a relation to volcanos in general, and are too intimately connected with the ſubjects hitherto treated of to be omitted, without juſtly incurring the blame of the reader. In various parts of this work mention has been made of the gaſes of volcanos. It has been ſhown that, by their elaſticity, ſtony ſubſtances fuſed in the fire are rarefied, inflated, and become cellular; as is proved by a great number of lavas, glaſſes and enamels. We have ſeen that, by the violence of theſe gaſes, the liquefied matters are haſtily raiſed from the bottom of the craters to the top, filling their whole internal capacity, and flowing over their ſides; ſince, by the action of the ſame gaſes, we frequently obſerve ſimilar pheno-

mena in the furnace. But, in the preſent age, in which naturaliſts and chemiſts are ſo earneſtly employed in analytical reſearches relative to the nature of aëriform fluids, it is not ſufficient to aſſert and prove the preſence of gaſes in liquefied volcanic products; it is likewiſe incumbent on us to endeavour to diſcover their peculiar nature, and thus prepare the means to aſcertain what part they may take in the eruptions of volcanos.

A ſecond intereſting object pointed out in the Introduction, and which well merits diſcuſſion, is the enquiry relative to the activity of volcanic fires. It is true, that from a number of experiments which I made in the furnace, both on volcanic productions, and on the primitive rocks, almoſt all of which I ſubjected to fuſion, it appears to be proved that this activity may not be very great; as a not very ſtrong common fire is ſufficient to produce the ſame effects. From theſe experiments we certainly acquire ſome knowledge of which we were not

not before in poſſeſſion; but I do not conſider the problem as undeniably ſolved; ſince to theſe facts a great number of others of a contrary nature may be oppoſed, of which, as they are related by writers well deſerving credit, I cannot omit the examination. I ſhall impartially conſider the weight of each, and afterwards give my ſincere and unbiaſſed opinion.

Theſe two ſubjects I ſhall proceed to conſider in two chapters, between which I ſhall inſert a very ſhort one, containing an account of a chemical diſcovery made in the courſe of my experiments. Theſe will conclude my enquiries relative to theſe truly terrific phenomena.

Having obſerved that the bubbles, vacuities and tumours, which are generated by aëriform fluids in many lavas, glaſſes, and enamels, are likewiſe produced by the ſame fluids in the ſame bodies, when expoſed to common fire; I determined to avail myſelf of that means to diſcover the nature of

theſe fluids. I reſolved, in conſequence, to fuſe within matraſſes various volcanic products; ſuch, eſpecially, as, by the ſuperabundance of their gaſeous bubbles, riſe from the bottom of the crucibles, and expand over them. I fitted the necks of the matraſſes to a chemical pneumatic apparatus with mercury, in order to collect and examine the gaſes which ſhould be diſengaged, by the action of the fire, from the liquefied ſubſtances. The matraſſes were of clay, of the ſame kind with that uſed for the receivers in which melted glaſs is kept for the making of different veſſels in a glaſs-houſe. They had a ſpherical bottom with a long neck, and were of the thickneſs of ſix full lines. I tried them by plunging them into water and blowing ſtrongly into them, when I did not find the ſmalleſt bubble of air eſcape. For the greater ſecurity I coated them externally, and tried them with the air-pump; but I did not perceive the leaſt hiſſing ſound that might indicate the eſcape of air. I repeated theſe proofs, likewiſe, after I had made my experiments, and thus

was

was certain that the fluids I found in the veſſels could not have entered them from without. To the neck of the matraſſes I luted a glaſs tube, the other extremity of which was inſerted in the mercury; in order that, if any liquor ſhould be ſeparated from the volcanic matters, I might collect it. Such a liquor was, in fact, ſeparated; and I found it to be of a nature which I never could have imagined. I ſhall deſcribe it in a diſtinct chapter, to prevent the confounding of objects totally unlike in one diſcuſſion.

The firſt product on which I made my experiments, was the ſixth ſpecies of the glaſſes of Lipari; that which I have deſcribed as having a black ground ſpotted with white points *. I placed twelve ounces of it in a matraſs, reducing it firſt to powder, as I did all theſe products, before I began my experiments, to deſtroy the bubbles that might have been produced by

* See Chap. XV.

the volcanic fires. The matraſſes were of that capacity, that the twelve ounces of every product ſcarcely occupied one third of their body; ſo that the melted matter might inflate and tumefy without impediment.

This glaſs I expoſed in a chemical furnace to a fire of eight hours continuance; three with a moderate, and five with a ſtrong heat. At the end of an hour and three quarters, there appeared upon the mercury a ſmall quantity of aëriform fluid, which, when examined, did not take fire at the flame of a candle immerſed in it, nor extinguiſh that flame, nor render it brighter, but left it preciſely as it was in the atmoſphere; conſequently this fluid muſt be conſidered as common air, that is, a portion of that contained in the veſſels uſed in the experiment. That ſuch was the fact, I was ſtill more convinced by ſubjecting this fluid to other experiments. Another ſmall quantity of fluid afterwards collected from time to time on the mercury, which I examined

as

as it was produced, but continually found it to be atmoſpheric air, which continued to appear during four hours after the fire began to act : in the laſt four hours none was produced.

Directing my eye along the glaſs tube luted to the neck of the matraſs, I could ſee the bottom of that veſſel by the light of the fire which ſurrounded it ; and, attentively obſerving it in that part, I began, after it had remained three quarters of an hour in a ſtrong fire, to perceive a ſlight inflation in the vitreous matter, which afterwards increaſed, and conſiſted of tumours that roſe extremely ſlowly from the ſurface of the fuſed glaſs, and ſunk again as ſlowly ; and ſome of which, having attained their greateſt dilatation, burſt. This kind of ſlow ebullition extremely reſembled that which, making uſe of the ſame glaſs and many other volcanic ſubſtances, I obſerved in the crucibles of a glaſs furnace ; it continued as long as the intenſity of the heat remained the ſame.

When

When the matraſs had cooled, I broke it lengthwiſe, and obſerved the following appearances: The glaſs when fuſed had filled two thirds and more of the body of the matraſs, to which it was ſtrongly attached, and formed in the upper part a plain ſurface, from which roſe a prodigious number of ſmall, vitreous, ſemitranſparent veſicles or bubbles, partly entire, and partly broken at the top.

On breaking the maſs of glaſs I found it entirely full of bubbles, of various ſizes, from thoſe which were only a third or quarter of a line in diameter, to thoſe which were half an inch. They all inclined, more or leſs, to an orbicular form, and their internal ſurface was ſmooth and ſhining. But on one ſide of the glaſs, which correſponded to the place where the fire was hotteſt, there was a bubble nearly as large as a hen's egg; in which was obſervable a thick vitreous thread, that croſſed it with the two ends adhering to its ſides, and which no doubt was produced by the viſ-

coſity

coſity of the matter at the time it ſeparated and formed this bubble.

Where the glaſs was not full of bubbles to the naked eye, it was ſufficiently ſolid and hard to give ſparks with ſteel ; I ſay, to the naked eye, becauſe, with the lens, the ſolid parts likewiſe were ſeen to be full of innumerable extremely minute bubbles.

When we compare the fuſion obtained in this matraſs with that obſerved in open crucibles, in a glaſs furnace, when the ſame ſpotted glaſs is the ſubject, we find the ſame reſults.

We will now proceed to treat on the origin and cauſe of theſe bubbles, which, in fact, is the principal object of our preſent enquiry. It ſeems undeniable that theſe muſt have been produced by an elaſtic fluid, which penetrated the glaſs when in a ſtate of fuſion, and compelled it to dilate in that manner. This ſuppoſition I have always made in the courſe of this work, when

when I have ſpoken of volcanic products become ebullient within the crucibles, and alſo of thoſe which have paſſed into ſuch a ſtate by the action of ſubterranean fires; nor do I conceive that it will be controverted by any perſons. Whoever has ſeen ſuch productions, will admit that this ſuppoſition is ſupported by the ſtrongeſt evidence.

But what may be the nature of this fluid? We cannot imagine it to be atmoſpheric air which occupied the pores of the pulveriſed glaſs contained in the matraſs, ſince this muſt have been expelled at the very beginning of the fuſion; whereas the tumours on the ſurface of the liquid glaſs were produced in the ſtrongeſt heat of the fire, and continued as long as it remained; an inconteſtable proof that, then, the fluid in queſtion copiouſly inveſted and agitated the vitreous maſs. This fluid, likewiſe, cannot be called permanent, like the different aëriform gaſes, ſince, were it ſo, it would have collected on the mercury. I therefore

began

began to ſuſpect that it muſt be an evaporation of the glaſs itſelf, which, in conſequence of the vehement heat, paſſed from the ſtate of fluidity to that of vapour or gas, and continued ſo while the degree of heat remained the ſame. Thus we ſee metals, acted on by a violent fire, boil and evaporate: and the opinion of Lavoiſier ſeems extremely probable—that almoſt all natural bodies are ſuſceptible of exiſting in a ſolid ſtate, the ſtate of fluidity, and the aëriform ſtate; theſe three different ſtates depending on the quantity of caloric combined with them. The evaporated glaſs, however, which cauſed the bubbles, did not paſs into the chemical-pneumatic apparatus, becauſe the heat near the neck of the matraſs, being leſs violent, was incapable of preſerving it in a gaſeous ſtate.

To aſcertain the truth of this conjecture, it was neceſſary to have recourſe to other proofs. I, therefore, proceed to the ſecond experiment, in which the circumſtances were the ſame as in the former; except

except that, during the laſt four hours, the fire was violent. The glaſs on which I made this experiment was the fifth ſpecies of the glaſſes of Lipari; which is the moſt perfect and the pureſt glaſs afforded by the iſland. The reſults were as follow:

The ſmall quantity of air which roſe above the mercury during the ignition was found to be purely atmoſpheric. After half an hour's violent fire, I perceived, through the glaſs tube inſerted into the matraſs, the vitreous maſs beginning to riſe in tumours, which preſently roſe ſo ſtrongly that I could only ſee a tumultuary inteſtine motion of the liquid fiery maſs. In theſe experiments I took the precaution to open, from time to time, the ſmall door of the furnace, to examine the appearance of the outſides of the matraſſes. After a continuance of a very ſtrong fire for two hours and three quarters, I perceived that the matraſs was broken, and that a long thread of glaſs had begun to iſſue through the fracture.

fracture. I therefore cauſed the fire to be extinguiſhed, and, after the matraſs had cooled, examined it within and without. I found, on one ſide, an angular fiſſure, fourteen lines in length, from which hung, externally, two thin cones of glaſs, which, however, was the only part of the fluid that had iſſued from the matraſs. Within was an oval bubble, occupying two full thirds of the body of the matraſs. This fact appeared to me of conſiderable importance. It is evident that this bubble was the effect of an aëriform fluid, which by its expanſive force had not only produced that vacuity, but broken the matraſs by ſtriking forcibly againſt its ſides. It is likewiſe equally clear, that this fluid could be no other than the glaſs itſelf, rendered here much more gaſeous from the greater violence of the fire. The remainder of the glaſs not occupied by that bubble was full of minute cavities.

The accident of breaking, accompanied with a very large bubble, happened to another matraſs containing an enamel of Iſ-

chia. Here, therefore, the ſtrong gaſification of the enamel, by the violent energy of the fire, had produced a vacuity which occupied more than half the matraſs, forcing up the enamel, and compelling it to aſcend through the neck; breaking at the ſame time the ſides of the matraſs.

In a fourth experiment I made uſe of an enamel of Procida. During a continuance of eight hours in the fire, I obſerved it attentively, but could not perceive any ſign of ebullition. I afterwards broke the matraſs, and found that, notwithſtanding its complete fuſion, and that it was in every part full of bubbles, the bubbles were in general ſmall. No particular gas appeared above the mercury.

Examining, afterwards, the internal ſides of the matraſs, above the hardened enamel, I made an obſervation that appeared to me important. A great number of very minute globules of the ſame enamel adhered, here and there, to the ſides, at the diſtance of half

half an inch, an inch, or two inches, from the enamel below. Beſides theſe globules a kind of thin ſtreaks of enamel were attached to the ſides; and where the neck was wideſt there was an accidental ſwelling, which formed a ring round the inner ſurface. Around this ring, on the ſide next to the body of the matraſs, was attached a very thin thread of the ſame enamel. It is not to be ſuppoſed that the enamel during its vehement fuſion could have riſen to the places where the traces of it ſo evidently appeared; ſince then the ſides would have been varniſhed over with it; as we ſee in crucibles in which the melted matter has riſen and ſunk again. Here, on the contrary, the ſides of the matraſs, in the places between theſe ſtreaks, were as perfectly free from any appearance of enamel, as they were before the experiment was made. I then could not but recollect the experiment of Lavoiſier, and others, of a plate of gold ſilvered over by expoſing it to the fumes of ſilver exhaling by the action of a vehement fire; as alſo another, its companion, in

which a plate of ſilver was gilt by a like effect of fire on gold. I concluded, therefore, that the globules and the other traces of enamel congealed on the ſides of the matraſs were the reſult of the ſublimation of the enamel itſelf at the time it was expoſed to the moſt violent heat.

A doubt however remained, which it was neceſſary to remove. It ſeemed not impoſſible that, in putting the pulveriſed enamel into the matraſs, ſome ſmall portion of the powder might have adhered to the ſides or the ſwelling in the neck, and afterwards have been melted by the action of the fire. But this doubt was completely removed by obſerving the ſame appearance on the ſides and neck of another matraſs, in which an equal quantity of the ſame enamel had been placed, not in powder, but in pieces.

This obſervation, which confirmed me in my opinion that the ebullition of ſubſtances fuſed in matraſſes was a conſequence of their vaporiſation, determined me to make a general

a general reviſion of the various crucibles I had before made uſe of in the furnace, and which had contained veſicular volcanic products; as I had not before examined them with a view to this object, believing that the veſicles or bubbles were cauſed by ſome permanent gas. There were not a few, to ſay the truth, the internal ſides of which exhibited, above the fuſed product, ſmall drops of the ſame ſubſtance: but it was eaſy to perceive that theſe were not collected there by ſublimation; but were thrown to that height by the inteſtine motion of the products in fuſion. There was, however, no crucible which preſented that thin coating, or that aggregate of infiniteſimal globules, obſervable in the laſt experiment, and which manifeſted an evident ſublimation of the fuſed ſubſtances. This, indeed, did not ſurpriſe me; as the crucibles were of a cylindrical, or inverted conical form, and open at the top; ſo that the particles which might ſublime met with no oppoſing body to detain and collect them.

I, therefore, reſolved to endeavour to aſcertain whether this ſublimation took place, likewiſe, in crucibles in the furnace when covered with other crucibles. I had nineteen in the whole, within which I placed thoſe kinds of volcanic matters which are moſt liable to inflate in large bubbles. On the ſides, and at the top of three of the inverted crucibles that ſerved as covers to the others, I perceived evident ſigns of ſublimation; in ſome fine vitreous traces, and a great number of extremely minute vitreous globules, which, in ſubſtance and colour, did not in the leaſt differ from the reſpective matters fuſed in the three crucibles. But nothing ſimilar was apparent in the other three crucibles. The former of theſe facts, which is poſitive, is a new and luminous proof of the gaſification of volcaniſed productions; and the latter, which is negative, no proof to the contrary; ſince, though every one of theſe ſixteen products were ebullient within the crucibles, and therefore, from what has been above ſaid, there is the ſtrongeſt reaſon to believe they were rendered ſo

by

by internal vaporiſation ; it is not neceſſary that they ſhould ſublime with evident external indications ; this depending on the nature of theſe ſubſtances ; ſome ſubliming with one degree of heat, and others requiring another and a greater. Hence we may perceive why, in the different experiments in different matraſſes, indications were not diſcernible of this ſublimation ; though I have no doubt that it would have been obtained likewiſe in them, had the fire been ſufficiently increaſed.

But to return to the experiments I was relating. After having made thoſe now deſcribed on volcanic glaſſes and enamels, I proceeded to ſubject to the ſame proof a factitious glaſs ; of that kind which is of a black colour, and has little tranſparency, and which is uſed in many countries to make thick bottles to contain wine. I took one of theſe bottles, which had never had in it any wine or other liquor, and placed twelve ounces of it, as before, in powder, within a matraſs. I had before obſerved that this

glaſs in the furnaces of Pavia requires a longer time to fuſe it than common white glaſs, and that in its actual fuſion it is little or not at all inflated. The fact, however, is, that after remaining the uſual eight hours in the furnace, the matraſs having been broken, the ebullition and exaltation appeared to have been ſuch, that the glaſs had riſen to the middle of the neck; though when the heat had ceaſed it had ſunk to the bottom of the belly. This was evident from a ſhining thin vitreous coating, occupying the whole interior ſurface of the matraſs, beginning from the level ſurface of the glaſs lying at the bottom, and proceeding to the middle of the neck, where there remained a lump of glaſs that entirely cloſed the aperture.

The appearances which took place in this factitious glaſs, both in the matraſs and the glaſs-furnace, may be underſtood and ſatisfactorily explained by the theory of the gaſification of the ſubſtances hitherto treated of. The heat of the furnace was ſufficient

to

fuſe this glaſs, but not to convert it into gas. The chemical furnace, being more active, rendered it gaſeous. Hence aroſe that violent tumefaction; though the action of the fire having afterwards diminiſhed, the glaſs conſequently paſſed from the aëriform to the liquid ſtate, and deſcended to the bottom of the matraſs, where it congealed. That no permanent gas had any part in this ebullition is proved by the mercurial pneumatic apparatus, in which it muſt have collected, more or leſs, above the mercury: but nothing was found except common air, as in the other experiments.

Hitherto I had only uſed thoſe volcanic products, which, in the furnace, are filled with bubbles more than others; being deſirous to obſerve whether the ſame effect would take place in the matraſſes, as was in fact the caſe. I afterwards reſolved to make experiments on others leſs liable to inflate in bubbles. To avoid needleſs prolixity, however, I ſhall only ſtate the qua-

lities of the ſubſtances I uſed, and the reſults obtained.

Theſe ſubſtances were ſix in number: a lava with garnets from Veſuvius; another, which, when I viſited that volcano, had recently flowed; a lava of Vulcano, inveſted with a cruſt of enamel; the lava continually ejected by Stromboli; the lava which, in 1787, iſſued from the higheſt crater of Etna; and a ſolid pumice of Lipari. I have already deſcribed each of theſe products, when treating of their reſpective volcanos.

After they had been expoſed to the fire eight hours, in matraſſes, nothing was found to aſcend above the mercury but atmoſpheric air, or a portion of that the veſſels contained. Theſe ſix products, therefore, afforded no indication of any permanent gas; but they evidently ſhowed that they had paſſed from the ſtate of liquidity to that of a ſtrong gaſification, from the quantity

quantity and ſize of the bubbles they contained. This is conſequently another and a moſt convincing proof, that a greater gaſification of ſtony ſubſtances may be obtained in a very ſtrong heat than in a weaker.

From theſe ten experiments I conceive myſelf ſufficiently warranted to conclude, that thoſe bubbles and inflations of various ſizes, which we ſo frequently obſerve in the products of volcanos, are by no means cauſed by the action of any permanent gas, but by that of an aëriform fluid produced by the exceſſive attenuation of thoſe ſame products in conſequence of heat.

I do not know that ſimilar experiments have been made by any other perſon excepting Dr. Prieſtley, who deſcribes three, which I think proper to be mentioned here, as they differ ſomewhat from mine. This naturaliſt, having fuſed in a ſand-ſtone retort $4\frac{1}{5}$ ounces of Iceland lava, obtained 20 meaſures of air, the half of which, about the beginning

beginning of the proceſs, was carbonic acid gas, and the remainder in purity 1.72; and extinguiſhed a candle. He remarked that the interſtices of this lava contained a ſand, which he was not able to ſeparate from it.

$5\frac{1}{2}$ ounces of lava of Veſuvius gave 30 meaſures of air; the firſt portion of which ſhowed a ſlight appearance of carbonic acid gas; and the remainder was azotic gas from the degree 1.64 to 1.38, with reſpect to what came laſt. The retort broke by the inflation of the reſidue, when it became cold.

Another ounce of lava, of the conſiſtence of a hard ſtone, gave only $3\frac{1}{2}$ meaſures of gas, principally hydrogenous, derived, as he conjectured, from the gun-barrel in which this experiment was made.

From theſe reſults the Engliſh naturaliſt infers, that it is probable that the true lavas do not afford much air; which, however, according

according to him, muſt depend on the degree of heat to which they have been expoſed in ſubterranean fires *.

Leaving unnoticed the laſt of theſe experiments, as being too equivocal, and conſidering only the two former, I could have wiſhed that Dr. Prieſtley had explained himſelf more fully relative to theſe two lavas; and afforded us certainty that the two ſtones on which he made his experiments were really volcanic.

But ſuppoſing they actually were ſuch, if we oppoſe our ten proceſſes to the two of Dr. Prieſtley, the conſequence to be derived will be, that volcanic products are not always deſtitute of permanent gaſes; which deduction will be found perfectly to agree with obſervations we ſhall have hereafter to make, and is by no means contrary to thoſe already made. In the latter, I have principally ſhown that the numerous pores in volcanic products expoſed to our common

* Experiments and Obſervations on Air, Vol. IV.

fire,

fire, and, conſequently, thoſe ſo extremely ſimilar frequently found in lavas, are probably not the effects of permanent gaſes, but of the gaſification of the lavas themſelves: and this diſcovery remains uncontroverted notwithſtanding the above-cited obſervations of Dr. Prieſtley.

I ſhall now proceed to enquire what part this aëriform vapour acts in the eruptions of volcanos. Where it exiſts in the depths of a volcanic crater, abundantly mixed with a liquid lava violently urged by ſubterranean conflagrations, I can eaſily conceive that by its energetic force it may raiſe the lava to the top of the crater, and compel it to flow over the ſides, and form a current. Art can imitate this great operation of nature, on an infinitely leſs ſcale. I placed in a glaſs-furnace a cylindric crucible, one foot high, and two inches and a half in breadth, which I filled half full with one of thoſe volcanic products which moſt inflate and boil in the fire. After ſome hours, I obſerved that the liquid matter began ſlowly to riſe, and afterwards to riſe higher until

it

it at laſt overflowed the edges of the crucible, forming ſmall ſtreams down its ſides, which, when they reached the plane on which the crucible ſtood, gave origin to ſmall currents, if that plane was at all inclined. When I put more of the ſame product into the crucible, the currents became larger. If the plane was then taken from the furnace, and the ſmall currents thus produced examined, they were found full of minute bubbles, as was likewiſe the matter which remained in the crucible. This curious experiment I made with ſeveral glaſſes and volcanic enamels, as alſo with a variety of cellular lavas, and always with the ſame ſucceſs.

It is likewiſe probable that this elaſtic vapour, when collected in a large quantity, if it finds under the earth any impenetrable obſtacle, produces local earthquakes, and ſubterraneous thunders and roarings; burſting open the ſides of the lava, and forcing out the lava. We have an example of this, if I may ſo ſpeak, in miniature, in the two matraſſes

matraſſes broken by this fluid from its exuberance and the reſiſtance it met with. I afterwards made in the furnace ſome experiments more deciſive. I cauſed three matraſſes to be made, on purpoſe, of clay, the ſides of which were an inch thick, and the belly, which I more than half filled with a cellular lava, four inches and three quarters in diameter; the neck projected in part from the furnace. At the end of eleven hours the three matraſſes were broken in the belly, with ſeveral fiſſures, through which the lava iſſued. Having afterwards broken up the matraſſes, I obſerved that they were entirely filled with a glaſs full of large bubbles, which did not extend beyond about half the neck, becauſe there the heat was no longer ſufficient to keep it in fuſion. It was eaſy to underſtand the cauſe of the matraſs breaking. The glaſs rarefied by the aëriform vapour, the belly being unable to contain it, had riſen into the neck; but loſing there its fluidity from the cold, it could advance no further; and, its inflation increaſing from the vehemence of the heat, the

the matraſs at length was forced to open. I find, therefore, no difficulty in believing that ſuch a vapour may produce ſimilar effects, on a larger ſcale, within the earth, when it meets any obſtacle to its expanſion.

I cannot, however, ſo eaſily admit that the ſame vapour is the cauſe of the fiery hail or ejections of volcanos, as the breaking of the matraſſes happens without the leaſt noiſe, and without the ejection or ſcattering of the contained matter. I attentively watched two matraſſes placed in the furnace when they began to open, and I obſerved that the apertures enlarged inſenſibly; which proves that the power of this vapour, though ſuperior to the reſiſtance of the matraſſes, acts nevertheleſs very ſlowly; whereas the agent which hurls the burning matters into the air from the volcanic mouths muſt act with the utmoſt rapidity and violence.

To explain theſe ejections, therefore, we muſt have recourſe to other principles. Modern

Modern volcaniſts have ſuppoſed that theſe are various gaſes, which, endeavouring to obtain a paſſage through the liquid ſubſtances in which they are enveloped, force them impetuouſly out of the crater, and ſometimes to an enormous height. The preſence of theſe gaſes is certainly not obſcurely manifeſted by the hiſſing ſounds that are heard during the raging of volcanos, as has been obſerved of Veſuvius, which, from its vicinity to Naples, is the volcano that has been moſt attentively examined. Similar hiſſing ſounds I likewiſe obſerved at Stromboli, of the eruptions of which volcano I ſhall preſently have occaſion again to ſpeak.

But what is the nature of theſe different gaſes? It is evident that to aſcertain this it would be neceſſary to collect them in the volcanic effervescences for a chemical examination, which is perhaps impoſſible, from the manifeſt danger there would be of falling a victim to ſo imprudent a curioſity. We can therefore obtain no knowledge of them

them but by an indirect way, that is, by obſerving the gaſeous ſubſtances which ariſe from volcanos when they have returned to a ſtate of tranquillity. If we peruſe the works of writers on this ſubject, we ſhall find ſeveral of them named; ſuch as hydrogenous gas, ſulphurated hydrogenous gas, carbonic acid gas, ſulphureous acid gas, azotic gas, &c. theſe different gaſes having been found in volcanic countries *.

But, beſides theſe concurrent cauſes, it is extremely probable that, in the greater and more terrible ejections, another more powerful principle comes in aid, which is

* From the agents which by their expanſive force produce the eructations of volcanos I do not mean to exclude caloric, which ſometimes muſt neceſſarily co-operate; that is, when in the volcanic receſſes a greater quantity of this fluid is ſuddenly diſengaged than can eaſily find a paſſage through the pores of the ſurrounding bodies. Then, as Lavoiſier has obſerved, caloric will act like other common elaſtic fluids, and overturn every thing which oppoſes it. Except in this circumſtance, however, I do not ſee what immediate action it can have in volcanic ejections.

water, principally that of the ſea. It would be ſuperfluous to ſhow, ſince it is generally known, that the volcanos ſcattered over the globe, and which at preſent throw out fire, are either ſurrounded by the ſea, or at a ſhort diſtance from it; and that thoſe which have long ſince ceaſed to burn are, for the moſt part, at a conſiderable diſtance from it. The conſervation, and we may likewiſe ſay the origin of theſe ſubterranean conflagrations, have therefore a ſecret relation to the waters of the ſea. There is little doubt but theſe waters communicate by ſecret paſſages with the ſpacious caverns and profound depths which exiſt, certainly, in burning mountains; and, though we are not able to diſcover this immediate communication from without, it is ſufficiently viſible by its effects; I mean the ſudden retiring of the ſea at the time of the moſt violent eruptions, occaſioned, probably, by the vaſt volume of its waters abſorbed in thoſe immenſe caverns. One of theſe retirings of the ſea, according to the obſervation of Pliny the younger, hap-

pened in the reign of the Emperor Titus, in that dreadful ejection of lava, ſmoke, and aſhes, which Veſuvius caſt forth, and in which Pliny the Naturaliſt periſhed. Another ſimilar took place in modern times, in the ſame ſea, during another terrible eruption of Veſuvius, as is recorded by authors worthy of credit who lived at the time. Serao, in his Relation of the Conflagration of Veſuvius in 1737, referring to the accounts of former conflagrations of that mountain, remarks, that "if not in all, at leaſt in the more terrible conflagrations, mention is made of the retiring of the ſea as a concurrent circumſtance." Steller, in his Obſervations on the Volcanos of Kamſchatka, remarks, that the greater part of earthquakes happen at the time of the equinoxes, when the ſea is moſt ſwelled, and eſpecially at the autumnal equinox, when its waters are higheſt.

It is therefore evident that a great maſs of water ſuddenly reduced to vapour by ſubterranean fires muſt cauſe prodigious ex-

ploſions, and detonations, far more violent than thoſe occaſioned by the elaſtic gaſes before mentioned. Thus, if a cannon, after having been fired ſeveral times, be ſpunged with a wet rammer which too exactly fits the calibre, the vapour produced at the bottom of the cannon, unable to eſcape as it expands, will force the rammer out with ſuch violence as ſometimes to carry away the arm of the gunner. If a ſmall quantity of water be incloſed in a globe of iron, or any other metal, ſo that the vapour cannot eſcape, and the globe be expoſed to a ſtrong fire, it will ſoon burſt with a loud noiſe, in the ſame manner as if the exploſion had been cauſed by gunpowder.

But nothing, in my opinion, more aptly ſhows the nature of the deſtructive exploſions which volcanos may produce by the evaporation of water, than the fatal accidents which ſometimes happen in conſequence of pouring melted metals into moulds not ſufficiently dried. An account of one of this kind may be found in the

fourth

fourth volume of the Memoirs of the Academy of Bologna, which I ſhall here briefly ſtate, as it is particularly applicable to the preſent ſubject. A bell of a very large ſize was to be caſt at Modena under a ſpacious portico. The metal was melted, and was let flow, through a ſmall channel, into the earthen mould, which was at a little diſtance under the pavement. But at the moment the melted metal reached the mould, ſuch a violent exploſion took place, that the metal, the mould, and a great quantity of earth, were thrown up with inconceivable violence. The furnace was blown in pieces; the portico, walls, and beams of the roof torn up and broken in many places; a large opening made in the roof, the tiles ſcattered about, and a wide and deep hole ſunk in the ground. Some of the byſtanders were killed, others ſeverely wounded and hurt, and all overwhelmed with dread and conſternation. Such dreadful effects were produced by a little moiſture being left in the earthen mould, through the inattention of the workmen. We may hence conclude

what terrible and deſtructive exploſions may be cauſed in volcanos by a large quantity of water entering among the ſubterranean fires.

Here a queſtion naturally ariſes, which it may not be unuſeful to diſcuſs. It can admit of no doubt, that water inſinuating itſelf under the burning matter, and ſuddenly reduced to vapour by the extreme heat, if it can obtain no paſſage, will cauſe the moſt terrible eructations. But what effect will it produce ſhould it fall upon the fire, ſuppoſing it either ſea-water or rain; for the latter may eaſily penetrate, through the pores and fiſſures of the earth, to the volcanic furnaces? If we attend to ſome experiments, we ſhall be inclined to ſuppoſe that the evaporation of the water in the latter caſe will produce the ſame effect as in the former. Thus, if we throw drops of water on an oily and boiling matter, ſuch as butter, fat, or oil, the water, by its violent expanſion in evaporation, will force out the oily particles with a kind of

exploſion

exploſion and ſhaking of the containing veſſels.

But other facts, more conſentaneous to the nature of volcanos, prove the contrary. It is well known to all mineralogiſts, that, if water be dropped upon melted copper or ſilver, the abundant vapours which ariſe will produce a kind of noiſe, but no exploſion.

The elegant experiments of Deſlandes, relative to the effects of water poured upon melted glaſs contained in capacious crucibles, in a glaſs-furnace, are equally deſerving attention in themſelves, and applicable to the preſent queſtion. I ſhall give a brief abſtract of them. A glaſs of water having been thrown on a quantity of melted glaſs, the water ſuddenly formed a globule without producing the leaſt ſound: it aſſumed, or ſeemed to aſſume, a red colour, ſimilar to that of the crucible and the melted glaſs. It rolled on the ſurface of the glaſs; and, nearly in the ſame manner as lead

is conſumed in the cupel, its volume gradually diminiſhed, until in three minutes it was entirely evaporated, without emitting any apparent fume. In another experiment the vitreous matter was poured upon a table, and made to flow, before the water was entirely evaporated: no detonation, however, followed.

The convenience of acceſs to a glaſs-furnace incited me to repeat theſe eaſy experiments, which have not, to my knowledge, been verified by any other perſon. Before I proceeded to make them, I ſpoke to one of the workmen on the ſubject, whom I found ſo well acquainted with the fact that he offered to pour as much water on melted glaſs as I pleaſed, aſſuring me that not the ſmalleſt ill effect was to be apprehended. I perceived, therefore, that this was one of thoſe phenomena which are publiſhed to the world as new, and which, in fact, are ſo to the learned, but have been long well known to many of the vulgar.

I began

I began my experiments with pouring ſix ounces of well-water into a cylindrical clay veſſel, about two feet in diameter, which had for fifteen days been nearly full of melted factitious cryſtal-glaſs. The water immediately diſperſed itſelf into a number of globules, in the ſame manner as mercury divides when thrown upon a plain ſurface. Theſe globules rolled about, gradually diminiſhing in ſize, and, in leſs than two minutes, diſappeared. All this time not the leaſt detonating ſound was to be heard; but, attentively obſerving the larger globules by the bright light of the furnace, I could perceive them in a ſtate of ſcarcely diſcernible ebullition. I repeated this experiment by emptying into the veſſel a pot containing eight-and-forty ounces of the ſame water, which now dividing into larger globules, enabled me to obſerve the appearances which took place in them with greater preciſion. At firſt the globules, moving as uſual on the ſurface of the melted glaſs, ſhowed no ſign of ebullition; but this, a few inſtants afterwards, became viſible, in

thoſe,

thoſe, at leaſt, that were neareſt to me; whence it may be concluded that the ſame happened in thoſe at a greater diſtance. They boiled and ſwelled perceptibly, but did not cauſe the leaſt ſound; the water being in a ſpace, if not deprived of air, at leaſt containing only ſuch as muſt be highly rareſied. They, however, as in the former experiment, continually diminiſhed in ſize, and, after about four minutes, entirely diſappeared. During their ebullition, no ſign of any vapour was diſcoverable around them.

It would be ſuperfluous prolixity to deſcribe ſeveral other experiments which I made with ſtill greater quantities of water, no difference being diſcernible in the reſults. I very attentively obſerved whether the water aſſumed a red colour, but ſaw nothing like it: this miſtake muſt have been occaſioned by the redneſs of the hot glaſs ſurrounding the water.

On comparing theſe facts with thoſe obſerved

ſerved by Deſlandes, I find them perfectly accord, except that the ebullition, which certainly takes place, was not obſerved by him. When we proceed to apply them to volcanos, with reſpect to the falling of water on their burning mouths, we ſhall be ready to conclude that water ſo falling cannot cauſe eruptions. To enable myſelf, however, if not to decide this queſtion, at leaſt ſomewhat more to elucidate it, I made ſome other experiments, both on different metals and lavas in fuſion. I made uſe of iron, copper, tin, and lead. With reſpect to the firſt, I employed filings of it, to facilitate its fuſion; as I have already remarked in the Introduction to this work, that, by this means, a deciſive principle of fuſion may be obtained in this metal in the furnace. The crucibles for theſe experiments were wide at the top, narrow at the bottom, and of conſiderable capacity; and I never entirely filled them with metal, that there might be room to pour on it a ſufficient quantity of water.

After

After the iron had remained twenty-four hours in the furnace, and was ſemi-fuſed, I let fall a few drops of water on it. They at firſt remained motionleſs, without apparently diminiſhing in bulk; but they ſoon after began to leap about and boil, waſting away, till, in leſs than a minute, they diſappeared. When I poured on more water the effects were the ſame, only the ebullition was more ſenſible, becauſe it was proportioned to the greater quantity of water.

Leaving the iron in the furnace, I, after ſeven hours more, repeated the experiment, having firſt removed the crucible into the cold air. I threw on the iron a ſlight ſprinkling of water; but this in an inſtant diſappeared without the leaſt ſound. I then poured the quantity of an ounce on it. For a moment the water remained quiet; it then divided into globules, and began to boil with ſome ſlight noiſe. In a ſhort time it entirely evaporated.

The redneſs of the iron was now ſomewhat obſcured; and I availed myſelf of the circumſtance to drop more water on it; but here the reſult changed its appearance. At the moment the water touched the metal it began to boil, and an undulating vapour aroſe, with noiſe, which continued till the entire diſperſion of the liquor. The heat of the iron continued ſufficient for me to repeat this experiment twice more with the ſame effect.

Copper in the furnace was completely fuſed. I made the ſame experiments on it, and with the ſame circumſtances as on the iron. I omit deſcribing the reſults, as that would only be to repeat exactly what I have ſaid relative to the former metal.

To make the ſame experiments on tin and lead, the furnace was not neceſſary, a much leſs heat being ſufficient for the fuſion of theſe metals. But I ſoon perceived that the confidence with which I had made my trials on the iron and copper, muſt not

not be continued with the lead, and ſtill leſs with the tin, on account of the violent exploſions excited by their touching the water. I made a great number of different experiments on both theſe metals; but, for the ſake of brevity, I ſhall only mention the principal.

When water was let fall, drop by drop, on melted tin in the crucible, it exploded with a loud noiſe, and pieces of the metal were thrown to the diſtance of two, three and four feet. If ſo much water was poured as to form a thin covering over a part of the ſurface of the tin, the detonation increaſed in proportion, and a great part of the metal was thrown out, with a loud exploſion, to a conſiderable diſtance from the crucible. Not the leaſt appearance of any vaporous fume was obſervable.

Approaching as near as this dangerous experiment would permit me, and attentively watching the progreſs of it, I obſerved, that as often as the drop of water touched the

the metal, the latter, by its fluidity, became in motion. I likewiſe remarked that, at the ſame time, a momentary cavity was produced in its ſurface, from the fall of the drop, eſpecially if it fell from any height. It then occurred to me, that it might be poſſible that the exploſion and detonation might be the effect of the water ſinking into the cavity, and being in part confined in the melted metal; where, paſſing ſuddenly into the ſtate of vapour, and finding no room for its dilatation, it impetuouſly forced out the metal. But this ſuppoſition did not accord with the fact. Had this been the caſe, if the drop had touched the melted tin without ſinking the ſmall cavity, it would have cauſed no exploſion; which muſt have been the louder and more violent the deeper the cavity, which would then have contained more water. I, therefore, firſt let fall the drops of water on the tin from a very ſmall height, and afterwards from one of five or ſix feet; but I found no ſenſible difference, either in the exploſion

ſion or ejections. The effect deſcribed, it may, conſequently, be concluded, was produced merely by the ſimple contact of the water and the tin.

I had, beſides, ſufficient proof that the water, when included within this melted metal, cauſes ejections much ſtronger and with a louder report. Having taken a crucible containing melted tin from the fire, the ſurface ſoon began to cool. I then with the point of a nail made a perforation through the cruſt that had gathered over it, which was ſtill thin and ſoft, and poured on it half an ounce of water, a part of which entered the perforation, when immediately the cruſt was forced up with an unuſual exploſion, almoſt all the melted metal violently thrown out, and the earthen crucible broken to pieces. The cooling and conſequent contraction of the cruſt had produced a vacuity between it and the melted metal, which admitted the water, but was much too confined for its expanſion

ſion when reduced to vapour, which, by its elaſticity, cauſed the violent effects that followed.

When the ſurface of the tin was cooled and conſolidated ſo that the water could not penetrate to the part which ſtill remained fluid, the latter only boiled, and reſolved into a ſmall vaporous cloud which roſe in the air.

In theſe exploſions, however, irregularities happen for which it is not eaſy to aſſign a reaſon. For example: after five or ſix exploſions had been produced by letting fall drops of water on the tin in fuſion, they would ſuddenly ceaſe, though I continued the fall of the drops, which, when they reached the metal, only boiled and evaporated. But what muſt appear moſt extraordinary was, that after three or four drops had produced no exploſion, others which fell immediately after again cauſed it. Nor muſt we imagine that the failure was occaſioned by the water falling not imme-

diately on the tin, but on the pulverulent pellicle with which it is inveſted by oxydation, ſince I carefully removed it as often as it was formed.

Melted lead exhibited the ſame appearances with the tin, and ſimilar irregularities, except that its exploſions with water were not ſo frequent, nor, as it appeared to me, ſo ſtrong.

I ſhall not here enquire why the water in the furnace exhibits no evaporation of any kind, nor boils till after ſome inſtants; whereas, when the experiment is made in the open air, the ebullition and evaporation follow immediately that the water touches theſe two metals, now ſomewhat cooler: nor why, when the water falls on lead and tin, it explodes with a loud noiſe, while no ſuch exploſion happens with copper and iron. Such reſearches, to be properly made, require other experiments, which would lead me too far from my ſubject. It appears to me preferable to proceed immediately

diately to relate what I obſerved in lavas in fuſion, contained in crucibles of the form and ſize before deſcribed, and tried by the ſame experiments which I had made on glaſs and metals.

The firſt I uſed were of that ſpecies which in the furnace become but little porous. The water, when poured upon theſe in a ſtate of fuſion, for ſome inſtants remained motionleſs; afterwards it began to boil, and the ebullition continued until it was entirely diſſipated. I repeated the experiment on the ſame lavas, after having taken them out of the furnace, and when they had in part loſt their glowing redneſs. The water, on touching them, aroſe in noiſy bubbles, producing a profuſion of vapours; and, as the lavas became cooler, the quantity of vapours became more abundant, at leaſt to a certain degree of coolneſs. Theſe lavas, therefore, did not differ from glaſs, copper, and iron, with reſpect to their cauſing no exploſion with water.

I next proceeded to the lavas filled with pores and bubbles; but here more caution was neceſſary. In one of them, two large bubbles appeared perforated on one ſide. On pouring the water into the crucible, it exploded with a noiſe equal to the report of a ſmall piſtol, and forced out the lava in ſcattered fragments. I was then convinced that this exploſion had not been produced by the water that had merely touched the ſurface of the lava, but by that which had penetrated into the two open bubbles. I had recourſe, therefore, to a proof which could not but be deciſive, which was, to repeat the experiment on the ſame kind of lava, but on ſuch as contained no fracture of any bubble, which may frequently be obtained among fuſed lavas of this ſpecies. When this lava was liquefied I let fall into the crucible the ſame quantity of water, which produced only a ſimple ebullition; and the ſame happened on repeated trials, which convinced me I was not miſtaken in my opinion.

I concluded theſe experiments with the following: Having fuſed a lava in a capacious receiver of clay, I perforated it obliquely from the top to the bottom by immerging in it a pointed iron wire three lines and a half in diameter. We ſhall ſee in Chap. XXIII. that the lavas which are moſt eaſily fuſible, and which are inflated and overflow the crucible, forming a ſtream down the ſides, retain, nevertheleſs, ſo great a tenacity in their parts, that they are with difficulty pierced, and that the cavity made by ſuch perforation remains entire but a very ſhort time. I reſolved to introduce water into this cavity; but as the experiment was dangerous, I removed the receiver from the furnace into a court-yard, and poured in the water by means of a long tube of iron, which reached the veſſel through a hole in the door that ſhut in the court-yard. As ſoon as the water entered the cavity, the pieces of the receiver and of the lava were forced violently to the diſtance of many feet, with a detonation equal to the report of a muſket.

While making theſe experiments, I wiſhed to ſatisfy my curioſity relative to another particular. Hitherto I had uſed freſh water from a well: and I wiſhed to aſcertain whether there was any difference in the effects produced by water from the ſea; ſince it appears highly probable that this water, by entering among the fires of volcanos, is the cauſe of their moſt terrible eructations. I, therefore, cauſed ſome to be brought, in cloſed veſſels, from the neighbouring gulph of Genoa; but, when I made uſe of it in ſimilar experiments on the fuſed lavas, I found the reſults perfectly the ſame with thoſe already deſcribed.

From this ſeries of experiments I think we are authoriſed to conclude, that when a quantity of water falls on the burning crater of a volcano, it has not the power of producing exploſions; but that the latter on the contrary are very violent when the water, penetrating below, reaches the conflagration; when ſuddenly reduced to vapour by the heat, it finds no room for its dilatation;

dilatation ; or when it infinuates itſelf laterally among the liquefied matters ; of which we have a ſatisfactory proof in the explo-ſion of the lava, violently forced from the containing veſſel, on the introduction of water into a cavity made in it.

Though, from the facts now adduced, there is the utmoſt reaſon to believe, that water changed to vapour, by the incredible power it acquires, is extremely well adapted to produce the great volcanic eruptions ; and, by the ſudden ſinkings of the ſea, which frequently happen on ſuch occaſions, it is nearly certain that they are to be aſcribed to this moſt powerful agent ; it is not neceſſary to recur to it for the cauſe of the more moderate and ſmaller ejections ; as, to produce theſe, the different permanent gaſes mentioned above are ſufficient ; and it is, in fact, beyond doubt, that they are the cauſes of ſuch eruptions in ſome volcanos, as, for inſtance, that of Stromboli. In Chap. X. we have ſeen that the ſymptoms of that volcano conſiſt in an ebullition

of the liquid lava within the crater, by which it roſe to a certain height, inflating with multiplied tumors, which burſt at the moment the detonation and ejection took place; that this was immediately followed by a ſinking of the lava to a certain depth, to which ſucceeded a new riſing of the ſame, with like inflations and tumors that burſt with ſimilar ejections and exploſion; and that in this alternation conſiſted the action of that volcano.

I have already ſuppoſed that theſe tumors are cauſed by an elaſtic fluid impriſoned within them, which endeavours to obtain a paſſage, and at length finds one, by burſting the tumors and forcing up their fragments to a conſiderable height; and this conjecture I then thought extremely well-founded, and am ſtill of the ſame opinion. It only remained to enquire what might be the nature of this fluid; which enquiry I reſerved to be made in the preſent chapter, in which I treat of the nature of the gaſes of volcanos. From the obſervations I made

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on the ſpot, I was ſufficiently convinced that the fluid contained in the tumors could not be derived from the evaporation of the lava, ſince this evaporation (which, from the facts adduced, cannot be denied) was, indeed, ſufficient to burſt them, but not to produce the ejections continually obſervable. Nor can we attribute them to evaporated water, as this would not have deferred its detonation when included in thoſe bubbles till it had reached the ſurface of the lava; but the exploſion and ejection would have taken place at the moment the water had come in contact with the burning lava, and, conſequently, at a much greater depth. Beſides, had that multitude of capacious tumors been filled with water which had paſſed into the ſtate of vapour, it muſt be manifeſt that every eruption would be much more violent and loud. We muſt therefore conclude that the fluid in queſtion is a permanent gas, and probably one of thoſe which are diſcoverable in volcanos when, in a ſtate of tranquillity, they are acceſſible,

ceſſible, ſuch as the carbonic acid gas, hydrogenous gas, oxygenous gas, &c.

In fact, M. Dolomieu, though he did not approach ſo near to the crater of Stromboli as I did, yet, from the obſervations he made, conjectured that its action was cauſed by hydrogenous gas. He ſuppoſed that the internal fire might diſengage this gas from the matters exiſting near, but not immediately touching, the volcanic furnace; and that this gas, by ſubterranean paſſages, might reach the principal cavity in which the conflagration rages, and there ſuddenly take fire.

This hypotheſis, which that judicious naturaliſt has propoſed only in the ſhape of a doubt or conjecture, is extremely plauſible, nor do I heſitate to believe that it is frequently the true explanation of what takes place in burning volcanos; though, with reſpect to Stromboli, it cannot be maintained when we compare it with the facts

facts obſerved. For, in the firſt place, though this gas has the property of riſing in flame, it has alſo that of extinguiſhing fire placed within its atmoſphere. How then can the lava melted in the cavern of Stromboli be penetrated, put in motion, and rarefied by this gas, without the diminution, not to ſay the entire loſs, of that ardent redneſs which I obſerved in it during the night? Secondly, though, in this volcano, the detonation is always inſeparable from the exploſion, we cannot ſuppoſe the former occaſioned by hydrogenous gas, unleſs we would admit an effect incomparably leſs than the cauſe. In the repeated viſits I made to that volcano, I obſerved that the ſtrongeſt detonations were not louder than the ſound of a very ſhort hollow thunder; and that, at the moment they are heard, the tumors which cover the lake of fiery lava, many of which are ſeveral feet in diameter, burſt. Is it not then evident that the ſuperabundant quantity of this gas, contained in ſo great a number of tumors, and fulminating almoſt at one inſtant, muſt cauſe

cauſe a much ſtronger detonation? But the proof that admits of no reply, or rather the abſolute demonſtration of the inſufficiency of this hypotheſis, is the following: When theſe tumors burſt by the force of the impriſoned fluid at the time it diſengages itſelf, were this fluid hydrogenous gas, it would take fire at the ſame moment, and cover with flame the ſurface of the lava; but it is certain that not the leaſt appearance of the feebleſt flame is diſcoverable in the lava in any eruption; as I can affirm from the various obſervations I have made, at a very ſhort diſtance, of the moſt minute accidents that take place within the crater.

Compelled, therefore, to abandon this explanation, it occurred to me whether atmoſpheric air might not poſſibly produce the phenomena in queſtion. I conſidered, however, that, before this hypotheſis was admitted, it would be neceſſary to ſhow that the atmoſpheric air had free acceſs from without the mountain to the volcano; that

that it inſinuated itſelf into the body of the lava; and iſſued out upwards, cauſing the inflations, ejections, and detonations. As to the poſſibility of its entrance to the moſt internal receſſes, containing the melted lava; it ſeemed to admit of eaſy proof from the cavernous ſtructure of volcanic mountains. But how this air could be ſufficiently powerful to inſinuate itſelf into the great maſs of lava, traverſe it to the top, and there occaſion the exploſions, I could not conceive, from the two following, in my opinion, inſuperable obſtacles. Firſt, it is undeniable that the atmoſpheric air which might penetrate through the cavities of the mountain, till it approached the immenſe maſs of melted and burning lava, would be extremely dilated, and make its way where it found the eaſieſt paſſage, which would be by the caverns that had admitted it; but it could never penetrate the lava, from its too great reſiſtance. Secondly, even granting for a moment that it might penetrate the lava, from the dilatation it muſt ſuffer, it would penetrate it extremely rarefied, and

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be incapable of producing the explosions continually observed at Stromboli. I omit several other objections, as I think these two are sufficient to demonstrate that this second hypothesis, likewise, cannot be maintained.

Shall I venture to propose a third, which, in my opinion, is not contemptible, though I offer it merely as conjectural? May not the phenomena of this volcano be attributed to the action of oxygenous gas? On the one side, it is well known that the sulphate of iron and the sulphate of alumine afford this gas in abundance, when acted on by a strong fire; and, on the other, it is equally certain that these two salts are copiously produced in volcanos. They may, therefore, in the profound recesses of Stromboli, furnish a rich and inexhaustible mine of oxygenous gas, which, mixing with the lava, and ascending through it by its levity, may collect, in a considerable quantity, in the narrow neck of the crater, and producing inflations and bubbles in the lava, force its

its way out with detonation, burſting and throwing up the fragments of the lava, from its expanſive force being greatly increaſed by heat. The ejections will be great, ſmall, or moderate, according to the different quantities of this gas collected and diſengaged.

Againſt this hypotheſis two objections may certainly be made; the one, that, admitting it, the ignited lava would be ſo bright that the eye could not bear to look on it; as we know that it is with difficulty we can bear to look on a ſmall flame animated by oxygenous gas; whereas, on the contrary, the redneſs of this lava is not greater than that of melted glaſs or metal. The other objection is, that the burning lavas acted on by this gas would be converted into a glaſs, or homogeneous enamel; whereas the lavas continually thrown out by Stromboli, beſides that the baſe of the primitive rock is ſufficiently recognizable in them, ſtill preſerve their ſhoerls and feltſpars in their original ſtate of cryſtallization.

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Both theſe objections, however, will, in my opinion, be found to have little weight, when we conſider that this gas in burning volcanos can never be pure, but muſt neceſſarily be mixed with ſome mephitic gas, and, eſpecially, with carbonic acid gas, which, in volcanic countries, is rarely wanting. By this mixture the vivid brightneſs which pure oxygenous gas would produce in the ignited lava, will be greatly weakened, and the action of the fire be prevented from being ſo violent as to deſtroy the characters of the primitive rock.

This hypotheſis, however, as I have ſaid, I offer only for examination, and ſhall be very ready to reject it ſhould it be found defective. The impoſſibility of collecting the fluid that eſcapes with detonation from this volcano, prevented me from aſcertaining its nature accurately. I am, therefore, obliged to ſeek it by conjecture, having recourſe to that elaſtic fluid, the exiſtence of which in the volcano of Stromboli I believe certain, and which, in ſome meaſure,

meaſure, at leaſt, may explain the phenomena.

At the ſame time it is to be obſerved, that we know not but that in thoſe immenſe laboratories of Nature which we call volcanos, certain gaſeous ſubſtances, hitherto unknown to us, may be produced or developed by the means of fire, and act a conſiderable part in their eruptions and exploſions. Of the exiſtence and nature of theſe ſubſtances, perhaps, we may not always remain ignorant.

CHAP. XXII.

DISCOVERY THAT VARIOUS VOLCANIC PRODUCTS CONTAIN MURIATIC ACID —ENQUIRY HOW THIS ACID HAS BEEN PRODUCED, AND MIXED WITH THEM.

An acid liquor extracted from the ſpotted glaſs of Lipari, during ignition—Proofs that this acid is muriatic—The ſame reſult followed on a repetition of the experiment—A ſimilar acid liquor produced from the black glaſs of Lipari—Factitious glaſſes do not furniſh it—Proof, both by the dry and humid way, that the muriatic acid is not combined with theſe two glaſſes, but only mechanically united to their parts—Seven other volcanic products ſubjected to the ſame experiments, from ſome of which the ſame acid liquor was obtained, and from others not—Diſcovery that this acid does not exiſt in volcanic products when in a ſtate

a ſtate of fuſion or ignition, but is introduced afterwards—This muriatic acid not derived from the muriate of ammoniac—It is probable that it proceeds either from ſubterranean places, or from the decompoſition of the muriate of ſoda.

NEAR the beginning of the former chapter, it has been obſerved that, when we enquired whether volcanic products, placed in matraſſes and expoſed to the fire, afforded any gas, and of what nature, a method there deſcribed was adopted to aſcertain whether any liquor was produced from the ſame. It was alſo mentioned that ſuch was obtained, which was found to be of a very ſingular character, and of which a deſcription was reſerved for another place, as we were then occupied in the details of the gaſifications of the ſaid products, and other particulars of the ſame nature. It is now proper to proceed to a more full deſcription of this liquor, and the circumſtances that accompanied it.

I ſhall begin by deſcribing the manner in which it was obtained from two ſpecies of the glaſſes of Lipari, the ſpotted and the black.

With reſpect to the former of theſe, when the fire began to heat conſiderably the matraſs, there appeared in the receiver a white cloud, which increaſed till it filled the whole cavity; and then gradually diſperſed, adhering to the internal ſides of the glaſs in the form of drops; and, after two hours and three quarters, entirely diſappeared, leaving at the bottom of the receiver a ſmall quantity of limpid liquor.

This liquor, on examination, manifeſted the following characters: Its weight was 144 grains; and its taſte was that of diluted muriatic acid.

The ferruginous pruſſiate of pot-aſh, not ſaturated, and the tincture of galls made with ſpirit of wine, do not ſhow any ſign of iron.

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The ammoniacal carbonate, in like manner, exhibits no appearance of earth.

The tincture of turnſole becoming red, ſhows that this acid is diſengaged:

Its efferveſcence with the ammoniacal carbonate, that it is not a weak acid.

Its not precipitating with the muriate of barytes, ſhows that this acid is not the ſulphuric.

The copious white fleeces produced with the nitrate of ſilver, prove that this acid is the muriatic.

Eighty grains of this liquor remained after I had made theſe experiments, and on this I poured nitrate of ſilver ſeveral times till no precipitation followed. This precipitate being edulcorated, dried, and weighed, was found to be eight grains: whence, the muriatic acid, according to the calculations of Bergmann, compoſing the fourth part

of the muriate of ſilver, the eighty grains of liquor muſt have contained two grains of this acid.

It is not eaſy to expreſs the ſurpriſe I felt at the preſence of this ſalt, and this water, within a ſtony ſubſtance which had not only been fuſed, but even vitrified by ſubterranean fires. It could not be ſuſpected that they had both adhered to the matraſs, ſince, beſides that it was a new one, like all the others employed in theſe experiments, this was the firſt time I had made uſe of it.

The extraordinary nature of the fact determined me to repeat the experiment with the ſame ſpotted glaſs. As I had ſeveral large pieces of it, I reduced a part of them to powder, which I put into another matraſs, and proceeded in the ſame manner as before. But, in this caſe, after half an hour's continuance in the fire, the white cloud began to appear in the receiver, which, at length, it entirely filled; and, afterwards diſperſing, covered the ſides with a water

a water which, falling down, produced at the bottom a tolerable quantity of liquor. I found its weight $77\frac{1}{2}$ grains. It had the uſual taſte of the muriatic acid; and the preſence of this and no other was confirmed by the re-agents I had applied to the other liquor. It was now, therefore, proved that this acid, united to water, was really contained in the volcanic glaſs. The appearance of white vapours in the glaſs receiver was thus explained; as they proceeded from the water mixed with the muriatic acid, it being well known that this acid, when it comes in contact with any humidity, produces ſuch vapours. The water reduced to vapour was condenſed by the cold of the receiver, and fell to the bottom; and the acid in queſtion, from its great affinity with it, was abſorbed by it.

But is this fact confined to this particular ſpecies of volcanic product, or does it extend to others? To aſcertain this was of ſome importance. I, therefore, made the ſame experiments on the black glaſs of the

ſame iſland. The reſult was not different. From twelve ounces of this glaſs I obtained 104 grains of a liquor which accumulated at the bottom of the glaſs receiver, by the condenſation of the white vapours, and the liquor manifeſted to the taſte the ſame muriatic acid, the preſence of which was confirmed by the ſame proofs as before.

Notwithſtanding the equality of the weight of the two glaſſes, the liquor obtained from the preſent weighed 40 grains leſs than that extracted from the other, but, when touched with the point of the tongue, taſted ſomewhat more acid. In fact, from 80 grains of this latter I obtained 10 grains of muriate of ſilver, in which there was, conſequently, $2\frac{1}{2}$ grains of muriatic acid, while the other only contained 2.

I afterwards made the ſame experiment on factitious glaſs; but, in this caſe, not more than a grain of water was collected in the receiver, and that was perfectly inſipid. It appears, therefore, that this acid appertains

tains to the two volcanic glaſſes, excluſively of artificial glaſſes.

It remained to attempt the ſolution of an important queſtion. Is the muriatic acid combined with theſe two volcanic ſubſtances, or only mechanically united? I conceived that ſome elucidation of this doubt might be obtained by expoſing one of theſe two glaſſes to a fire not ſufficiently ſtrong to cauſe fuſion. I put ſix ounces of the ſpotted glaſs, reduced to powder, in a glaſs retort with a luted belly; joining to it the glaſs receiver, communicating as before with the mercurial apparatus. This I heated in a ſand-bath for twelve hours ſucceſſively. At the end of an hour and a half there appeared, in the neck of the retort, a large drop of limpid liquor, which ſoon after fell into the receiver. Afterwards a ſecond formed in the ſame place, which remained adheſive, no other humidity ariſing to increaſe it. No vapour of any kind was viſible in the retort or the glaſs receiver, and it was not till after the firſt two hours that the

the neck of the retort began to be covered with a white veil, which afterwards became more denſe. No kind of gas was formed on the mercury.

Having broken the retort, I found that this veil was only the more ſubtile part of the pulverized glaſs, ſublimed by the heat, and remaining adheſive to the retort. No fuſion followed in the glaſs. The two drops of water, which might amount in quantity to nine or ten grains, were extremely acid to the taſte, and it appeared from the application of re-agents that the acid was purely muriatic.

The glaſs remaining untouched, this experiment ſhowed that the water and the muriatic acid were not in combination with the parts of the glaſs, but only adheſive to them ; it appeared, likewiſe, that the quantity of acidulous water produced was not equal to that obtained in the matraſſes, becauſe the heat was not ſo great.

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The humid way afforded a ſtill further elucidation. Having reduced to powder twelve ounces of the black, and twelve of the ſpotted glaſs of Lipari, they were left ſeparately during twelve hours in digeſtion with heat in diſtilled water. The water, when filtrated, did not in the leaſt change the colour of the tincture of turnſole; a proof that in it there either exiſted no acid diſengaged, or that it was extremely weak. On trying the ſame water with nitrate of ſilver, a ſlight turbidneſs was produced; and, after four-and-twenty hours, an extremely ſmall ſediment.

As I knew that the muriatic acid, though weak, always produces white fleeces or ſtreaks in the ſolution of the nitrate of ſilver, I entertained ſome doubt whether this turbidneſs might be the effect of this acid; and, to remove it, I reſolved to try whether a ſimilar turbidneſs, but without fleeces or ſtreaks, might not be produced by nitrate of ſilver in diſtilled water in which a drop of muriatic acid had been infuſed. On making

making this experiment I found that the fleeces, on increaſing the quantity of water, became leſs ſenſible in the infuſion of ſolution of ſilver; and, adding ſtill more water, a ſlight turbidneſs was at length produced without fleeces or ſtreaks: whence it appeared evident that the turbidneſs in queſtion was the effect of a very ſlight portion of the muriatic acid, which had paſſed from the volcanic glaſſes into the water.

I took twelve ounces of each of the glaſſes, the ſpotted and the black, reduced them to powder, and boiled them ſeparately in diſtilled water four ſucceſſive times, fifteen hours each time; then ſtraining off the water, I evaporated it to dryneſs, and found at the bottom of the veſſel a reſidue of fine glaſs-powder. On this I poured a little diſtilled water, and tried one part of this water with the tincture of turnſole, and the other with nitrate of ſilver. In the former aroſe a thin reddiſh fume, and in the latter a ſlight turbidneſs, not without a few white fleeces.

I took

I took 19 ounces, 2 drams, and $7\frac{1}{2}$ grains of black glaſs of Lipari, broke it into ſix pieces, put them in diſtilled water, and left them during forty hours in a ſand-bath, but without boiling. I did the ſame by a quantity of the ſpotted glaſs, broken into ſeven pieces, and weighing 20 ounces, 2 drams, and $1\frac{1}{2}$ grain. Having dried the two glaſſes in the air and the ſun, I found them of the ſame weight. Into theſe two waters, diminiſhed by evaporation, I poured the nitrate of ſilver, which cauſed a ſlight turbidneſs, and a proportionate ſediment.

By all theſe facts I think it is inconteſtably proved that the muriatic acid, in theſe two volcanic glaſſes, is not combined with them ſo as to enter into them as a conſtituent principle; but is only mechanically attached to their parts.

Beſides theſe two glaſſes, the black and the ſpotted of Lipari, I made experiments, as I have mentioned in the preceding chapter, on ſix other volcanic products. The

gaſeous

gaſeous ſubſtances obtained from them have been already deſcribed. It now remains to ſtate the reſults relative to the preſent enquiry.

From the lava of Veſuvius, containing garnets, was obtained in the receiver two grains of water, which did not in the leaſt change the tincture of turnſole, but produced a light-blue milkineſs by the mixture of nitrate of ſilver. It could not, therefore, be ſaid that this lava was entirely deſtitute of muriatic acid.

The lava of Veſuvius which had flowed a ſhort time before I viſited that volcano, left at the bottom of the receiver four grains of water, which, when tried by the re-agents, was found not to differ from the diſtilled water.

From the lava of Vulcano, which is externally an enamel, I obtained $4\frac{1}{2}$ grains of water, which was without odour, but ſomewhat acidulous; and the precipitation in white fleeces, cauſed by the nitrate of ſilver,

ver, proved the preſence of the muriatic acid.

The lava of Stromboli, thrown out of its crater, furniſhed two grains of pure water.

Another lava of Stromboli, of the ſame ſpecies, but which, from its being found buried deep beneath other lavas, muſt evidently have been thrown out before they were, produced $7\frac{1}{4}$ grains of water in which was contained a portion of muriatic acid; as was diſcoverable by touching it with the tongue, and ſtill more deciſively by the fleecy ſtreaks produced by the nitrate of ſilver.

The lava which iſſued from Etna in the year 1787, and which, like that of Stromboli, was ſtill warm when I collected it, gave water to the amount of 6 grains, which in every reſpect reſembled diſtilled water.

From a ſolid pumice of Lipari I obtained $24\frac{3}{4}$ grains of water, which was acid to the taſte, changed the tincture of turnſole to red,

red, and the acid of which was manifeſtly muriatic, from the fleecy turbidneſs produced by mixing it with the nitrate of ſilver.

On comparing all theſe facts, it appears that, of nine volcanic products expoſed to the action of the fire and fuſed, ſix manifeſted the preſence of the muriatic acid, and in three not the leaſt ſign of it appeared. From a compariſon of the local circumſtances of theſe nine products, we muſt be convinced that the muriatic acid does not exiſt in theſe products when they are either fuſed, or heated to redneſs; but that it unites with them afterwards, ſince the three lavas, one from Veſuvius, another from Stromboli, and a third from Etna, which had been recently ejected from the ſubterranean furnaces, contained none, though they afforded a ſmall portion of water; while the ſix others which had ceaſed to burn for a longer or ſhorter time, gave a greater or leſs quantity of this acid. It is alſo a confirmation of this fact, and merits attention, that the ſame lava of Stromboli

was deſtitute of it when firſt ejected; but, after ſome time was elapſed, began to acquire it.

The idea occurred to me whether this acid might not be derived from the ammoniacal muriate, as this ſalt is almoſt always found in volcanos. I, therefore, poured a ſmall quantity of the acid liquors obtained from the two glaſſes upon lime without making uſe of the carbonate of pot-aſh; but I did not perceive any thing of the ſtrong odour of ammoniac; an evident proof that it was not the ammoniacal muriate.

I rather incline to ſuppoſe that this acid originates either from the ſubterranean places in which we know that it is ſometimes found, or rather perhaps from the ſea penetrating beneath the volcanic mountains; that it is generated from the decompoſition of the muriate of ſoda, by the means of ſulphureous acids in which volcanos abound; and that, abſorbed by the humidity of the

air, it is introduced with it into the volcanic products. I cannot, however, deny but that it muſt appear ſurpriſing that this ſalt in conjunction with water ſhould have been able to find an entrance into the two glaſſes of Lipari; and eſpecially the black ſpecies, as it is extremely compact, and has not the leaſt appearance of any cleft or crack. But we know that water can ſubtilize itſelf in ſuch a manner as to penetrate other bodies equally ſolid and compact, in which our eyes, though aſſiſted by a lens of a ſtrong magnifying power, cannot diſcover the ſmalleſt fiſſure or minuteſt pore.

END OF THE THIRD VOLUME.

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